The
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The Rampant Undesirable African Weed Orchid
Monadenia bracteata is Spreading in Victoria

Mrs E.L Robertson, coordinator of the African Weed Orchid Eradication Program in South Australia, has alerted us to the fact that this weed *Monadenia bracteata* has now been reported in Victoria - escaped from cultivation in a Melbourne suburb - and is now found in the Victorian border forest near the Lower Glenelg River.

Since the weed was first reported in Albany (Western Australia) in 1944 it has spread east of Esperance and north of Perth and has infested Western Australia. From the first appearance of the African Weed Orchid in South Australia in 1988, it has now spread widely in that state.

This weed has the potential to threaten and crowd out native understorey species. There is no specific chemical control that will not also kill native lilies and orchids, therefore, the African Weed Orchid needs to be removed by hand.

The flowering spikes appear in late September/early October and the plant should be removed before the seed sets and a new batch of air-borne seeds take flight. Dig up the whole plant, including the tubers, and destroy it.

As with other virulent weeds, it needs to be removed as soon as it is found.

For more information, contact

Mrs Robertson , 9 Sherbourne Road, Blackwood, South Australia 5051.

The African Weed Orchid *Monadenia bracteata*

Flowering spike.

Fruiting spike.

Correction

Bill Molyneux has drawn out attention to the fact that a reference to the standing of the Australflora Nursery in the profile of Rodger Elliot (*The Victorian Naturalist* **112**, 1995, 188) may have been misconstrued. Mr Molyneux has been associated with Austraflora since 1969, acquiring the business in January 1973 (when he was joined by Sue Forrester), and the land in 1982. We apologise for any misunderstanding which may have occurred.

Sheila Houghton
Secretary to the Australian Natural History Medallion. General Committee.

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Cover: The Blue-banded Bee *Amegilla cingulata,* see article on page 7.
Drawing courtesy CSIRO, Division of Entomology; Artist M.Quick

Significance of Honey Bees in the Australian Environment: Setting the Scene

T.R. New[1]

Introduction

Australia is susceptible to invasion. Since European settlement, animals and plants from other parts of the world have come to dominate much of the island continent but, whereas species such as rabbits, foxes, cattle, Indian Mynahs, European Carp, blackberries and Boneseed are well-known, many other so-called exotic taxa are not as well understood or so conspicuous. The environmental changes wrought over the last two centuries have created suitable facilitating environments for many such colonists, whether they have arrived by accident or have been introduced deliberately. Many of them have remained associated with such anthropogenic regimes as agricultural systems and urban regions. Others have become aggressive invaders in spreading to more natural ecosystems where they have the potential to interact, in various ways, with native endemic biota. Thus, whereas most aphid species in Australia are exotic species which depend on introduced host plants, including many of our crops and garden ornamentals, other insects more resemble the trends demonstrated, for example, by rabbits or some environmental weeds in becoming more widespread, and engender concern over their actual or supposed effects on sensitive native animals and plants.

Many insects found in Australia are not truly native to the country (New 1994). Evaluating their impacts is important in planning conservation needs for our endemic species and, in general, 'alien species' are one of the greatest perceived threats in modern conservation management. Further, the isolation of Australia may render it especially susceptible to their effects.

However, many exotic species are viewed positively and encouraged actively by people, even when there is evidence that their ecological effects may not benefit the Australian environment. Trout, for exam-

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ple, continue to be dispersed actively into waterbodies to support recreational fishing, despite their implication in the decline of a number of endemic freshwater invertebrates (Fletcher 1986). Some existing trout populations would be difficult or impossible to eradicate but, whereas this might be the ecologically responsible aim, trout are actively encouraged by people who derive benefit and pleasure from their presence. The insect which is treated in the following essays falls into a similar category of perception. There has been considerable debate over the effects of Honey Bees *Apis mellifera* in the Australian environment, with the apiary industry coming into some conflict with concerned conservationists over possible harmful effects to native biota. The debate has hardened in recent years over whether the industry should be permitted to operate in, or close to, National Parks and other protected areas in which assured nectar supplies may be available (in contrast to surrounding areas with few trees), but which are also sanctuaries for native pollinators and plants. In Victoria, beekeeping has been traditional in many parks, with the Land Conservation Council long recommending that this practice continue where it is compatible with the major objectives of nature conservation and provision for public recreation. However, they noted also (1988) that 'a conservative approach to beekeeping is warranted until longer term studies establish otherwise'.

The following papers address and evaluate some of the issues involved, and this brief introduction provides some of the background needed to appreciate the concerns which led to their gestation.

Social insects as invaders

'Many species of social wasps, bees and ants are extraordinarily invasive' (Moller 1996). Introduced species of these Hymenoptera often become important pests, but our major concerns here are that their invasions may pose threats to conservation by affecting species which are char-

acteristic of the receiving communities. And, as Moller (1996) emphasised, their control is difficult, so that most invasive social insects become permanent additions to the new fauna. Honey Bees and other social insects form colonies within which there are castes (that is, groups of individuals with different functional roles), co-operative behaviour and a division of labour, and the 'population' is perhaps better viewed as the number of colonies rather than of individual insects present. Because of the ecological flexibility and buffering against environmental extremes fostered by colonial existence, social insects can reach high densities. They are viewed commonly as efficient exploiters of natural resources and thus as formidable competitors (Moller 1996). Sociality allows greater invasion success than for many solitary insects (New 1994), and various exotic ants have displaced native species in many parts of the world (Williams 1994). The Argentine Ant *Linepithima humile,* for example, can displace native ant species in the areas it invades. However, whereas the spread and impacts of some social insects, such as the European Wasp *Vespula germanica* in New Zealand, have been documented in detail (Harris 1991, Moller and Tilley 1989, Moller *et al.* 1991, and others), other insects have spread more insidiously and have established in the wild or been accepted uncritically well before any retrospective documentation is needed or attempted. This is the case for *Apis mellifera* in Australia.

Honey Bees in Australia: history and issues.

There are two rather different components to Australia's Honey Bee population. The first and more familiar is the basis of the apiary industry which has a substantial component of migratory beekeeping, whereby hives are shifted several times a season to track nectar and pollen supplies, and to facilitate pollination services. The second component, commonly disregarded, is the evolution of a large feral population that utilises natural nesting sites and has a generally broad and uncontrolled distribution. Honey Bees were first brought to Australia (NSW) in 1822, and there is little doubt that feral populations

were initiated in eastern Australia within a few decades. For the most part, these have been ignored until recently. Likewise, no debate as to the the the effect of continuing expansion and spread of beekeeping has been forthcoming until the last decade or so, when some ecologists began to fear the process of 'faunal homogenisation' and gave warnings of the impacts of exotic social insects elsewhere in the world, as part of the increased spread of invasive organisms. Serious suggestions of adverse effects of Honey Bees on Australian native biota commenced in the 1970s.

These allegations led to heightened tensions between apiarists and conservationists. Many of these issues were discussed at a national workshop on 'Commercially managed Honey Bees in the Australian environment' organised by the Honey Research Council in 1989, at which the large gaps in our knowledge and understanding were highlighted. The major topics raised by the scientists at that meeting which need critical study include (1) the dynamics of nectar and pollen production and use; (2) the effects of adding commercial bees to any native biota, and (3) the biology of feral Honey Bee populations, together with assessment of their effects on fauna and flora, and methods of control. There was also a perceived need for critical appraisal of some previous key studies, and for sound experimental research to test hypotheses on possible adverse or competitive effects (involving both exploitation of resources and interference with other species). Studies on how the nectar resource is produced and exploited are a critical focus for investigation, and would include manipulative studies, whereby Honey Bee populations were augmented or depleted locally to measure their effects on particular resources, or at particular sites.

Concerns were also expressed over possible disruption to the breeding systems of rare or highly localised plants of conservation interest, and the roles of feral bees in usurping tree holes needed as nest sites by birds or marsupials. It is also important to clarify possible adverse effects on the large number of native pollinating insects, especially the diverse Australian bee fauna. These are all key topics in determining whether increased exploitation by the api-

ary industry should be condoned in reserve areas.

In his lead discussion paper at the workshop, Hamilton (1989) summarised the overall main concerns as:

1. Possible impact of bees themselves on flora and fauna.
2. Damage by the beekeepers in gaining access and carrying out their operations on apiary sites.
3. That Honey Bees are exotic and have no place in certain reserves.
4. That commercial activities such as beekeeping have no place on conserved land.
5. The hazard of bee stings to the public.

The concerns may be summarised more succinctly (after FCAAA 1987, my additions in parentheses):

1. Reduction in the available nectar for native nectar foragers (?reduction in the amount of nectar present at any one time).
2. Inefficient pollination of native flora (?nectar removed without pollination, ?flowers destroyed).
3. Hybridisation of native plant species (?may be increased by Honey Bee visitation).
4. Longterm decline of native pollinators (?reduce survival potential through food depletion and physical interference).
5. Competition for nest sites (?dispersal of swarms to tree hollows and like sites in spring).
6. Plant pathogen spread (?by bees and apiarist's vehicles).

These themes need to be addressed to assure optimal conservation of flora and fauna, and also to ensure that the beekeeping industry is not jeopardised - so that the solutions require a marriage of sociological and scientific ideals. The three papers which follow are likely to be significant in helping to enlighten the continuing debate.

However, the twin contexts of apiary and ferality are rather different, and need to be distinguished carefully. The former is the major concern of the industry in seeking to expand its resource base. In Australia, there were about 2,000 commercial or semi-commercial beekeepers in 1987-88 (Hamilton, 1989). Wills (1989) noted 408 in Victoria, operating a total of more than 84,000 hives in the 1980s. In Victoria, an 'average commercial apiarist' may occupy up to about 20 individual sites (on an intermittent basis, and not all used every year) in shifting hives several times a year to track seasonal patterns of nectar and pollen produced by different flora on a predictable schedule. The overall area needed each year by such an operator is about 16,000 ha (FCAAA 1987), and between 400 and 800 hives may be involved. The bulk of the resources are derived from eucalypts and, should the industry be excluded from conserved forests, alternatives may not be available and the industry may be forced into decline. The precise value of the apiary industry is very difficult to determine, and depends largely on the rather intangible values ascribed to pollination services, estimated some years ago as in the order of $150-400 million a year. This is by far the largest component of benefit, compared with around $30 million a year for honey and a million dollars for wax.

Feral bees are already widespread, and the problems devolve to whether it is necessary to eliminate (or try to eliminate) them from sensitive areas, and to avoid further recruitment (with possible envigoration by interbreeding, and enhancement of undesirable effects) through apiary swarms. Feral Honey Bees are present in most suitable forest/woodland systems where permanent water is available, but whether any adverse effects are increased by overlaying these possibly 'in balance' populations with increased densities from apiary activity has yet to be determined.

Finally, although the Australian situation was not considered specifically, several papers in a recent symposium on Conservation of Bees (Matheson 1996) warned of the dangers of introduced Honey Bees in other parts of the world, and also stressed the need for sound studies to determine any adverse competitive effects with native biota. Similar caution should be applied to any other deliberately introduced exotic species but, as implied earlier, some Hymenoptera might prove especially problematical. Despite its rather different biology, fears were expressed over possible deleterious effects of the Leafcutting Bee *Megachile rotundata* prior to its introduction to South Australia in 1987. It was recognised that this species, also, might

become feral and compete with native bees. Observations to date suggest that it has had little effect (Woodward, 1996).

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Effects of Introduced Honey Bees on Australia's Native Bee Fauna

Michael P. Schwarz[1] and Pamela S. Hurst[1]

Abstract

The introduced Honey Bee, *Apis mellifera*, has been present in Australia as both a commercially managed and feral species for over 150 years and there is considerable concern that it may have negative impacts on Australian flora and fauna. We briefly describe several aspects of Australia's native bee fauna and then discuss the potential for resource competition between honey bees and native bees. Three factors which may augment the competitive ability of Honey Bees compared to native bees are outlined: the extended foraging periods and seasonal activity of Honey Bees; their ability to rapidly recruit foragers in the exploitation of food sources; and their ability to forage over long distances. However, the few Australian investigations into resource competition between Honey Bees and native bees have been inconclusive. In some cases experimental designs were inadequate, and in all cases, study sites were in areas with relatively rich floral resources. It is proposed that competition for floral resources will be greater in areas of low floristic abundance and that future studies should examine the effects of Honey Bee presence in these areas. In addition, bee species with a restricted range of food resources, such as some short tongued bees, may be more susceptible to competition and therefore warrant investigation. Finally, the problem of controlling feral Honey Bee populations is discussed (*The Victorian Naturalist* 1997, **114**, 7-12).

Introduction

Since the introduction of the Honey Bee, *Apis mellifera*, to Australia in the early 1800s and its subsequent spread to virtually all non-arid regions, there has been growing concern that this exotic species may have substantial negative impacts on native fauna and flora. The potential for impact may seem obvious to even the casual observer - Honey Bees are virtually ubiquitous and frequently the most abundant insects visiting flowers. One would expect that any negative impacts would be greatest for those animals that overlap most strongly in food resources, the native bees, but there is also potential for some bird and mammal species to be affected.

The Australian native bee fauna.

It is ironic that when most people think of bees, they think of the introduced Honey Bee. Many people think of 'native bees' as either feral Honey Bees or the small number of indigenous stingless Honey Bees

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found in tropical and subtropical habitats. However, Australia has a very rich native bee fauna with over 1,500 species (Cardale 1993), and our fauna is probably the most distinctive one in the world (Michener 1965). Bees are basically sphecoid wasps which have evolved to use flowers as sources of both protein and carbohydrate. Protein is obtained in the form of pollen, and carbohydrate is principally obtained as sugars from nectar, although some bees also utilise extra-floral nectaries. One of the most distinctive features of bees is the presence of 'scopae' - branched hairs on the legs, abdomen or thorax that allow the bee to collect and transport pollen back to the nest. These scopae give most bees a characteristic 'furry' appearance, in contrast to the sleek appearance of wasps. However, not all bees carry pollen on scopae: two major Australian colletid groups, the Euryglossinae and the Hylaeinae, swallow pollen at the flower, transport it in their crops, and regurgitate it in their nests. In addition, some bee species have become parasitic and invade the nests of other bees, where their brood use food collected by the host bees.

The Australian bee fauna is unique in that it is largely dominated by short tongued bees from the families Colletidae (usually regarded as the most primitive group of bees) and Halictidae. The short mouthparts of these bees means that they are usually unable to access nectar produced by plants which have flowers with long narrow corolla tubes (for example *Frankenia*, although a small number of colletids have modified mouthparts allowing them to feed from these flowers). Interestingly, the predominance of colletids and halictids in Australia may be linked to the abundance of myrtaceous plant genera (eg, *Eucalyptus* and *Leptospermum*) in Australia. Flowers of most Myrtaceae present their nectar in broad, shallow cups, allowing colletids ready access. Whilst the Colletidae in Australia is more abundant and diverse than in any other continent, we lack two other families that are common elsewhere, the Andrenidae and Melittidae. Other groups common in Australia include the blue-and-white striped genus *Amegilla*, and the red and black bodied *Exoneura* (common along the Great Dividing Range and in subcoastal heathland).

Very few Australian native bees live in hives. Rather, most species live in branching burrows in the ground, or in simple tunnels in the dead stems of plants. Most species have very small colony sizes and forms of social organisation that are often regarded as being primitive, viz.; (i) many species are solitary, ie. only one bee (female) per nest; (ii) other species, particularly ground nesting species, have communal colonies; in these species anywhere from 2 or 3 to possibly hundreds of females may utilise the same nest, but each female lays her own eggs and rears her own brood; (iii) in some species there is a weakly defined social organisation within colonies, where some females specialise in egg-production, others in food collection, and others in guarding duties. Stem nesting allodapine bees are a group of bees which display weakly defined social organisation (Fig. 1).

Because of the small number of Australian researchers working on native bees and the large number of species, the Australian bee fauna is poorly understood, both in terms of social behaviour and pollination ecology. It is likely that many Australian plants and bees have co-evolved, resulting in intricate relationships of which we know little. For example, one group of ground nesting halictine bees are only found on *Wahlenbergia* flowers (Michener 1965). Also, some plants like *Stylidium* (the Trigger plant) show highly specialised structures that appear to be adaptations to small-bodied native bees, such as *Exoneura*. One concern is that Honey Bees may not effect pollination for a variety of native plant species, but may nevertheless deplete the nectar rewards used by native pollinators (eg. Taylor and Whelan 1988).

Potential for resource competition between Honey Bees and native bees.

The major potential for negative impacts of Honey Bees on native bees revolves around their common food resources - pollen and nectar. If pollen and nectar are in short supply, there is the potential for Honey Bees to exploit these resources to the point where native bees are unable to reproduce at the same levels as prior to the introduction of Honey Bees. The possibility for such competition is heightened
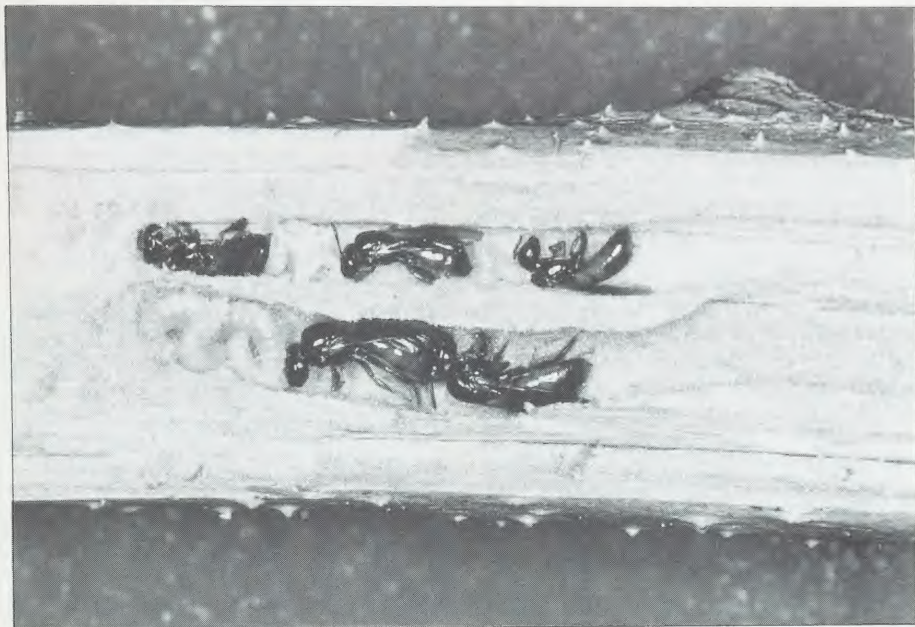
Fig. 1. Photograph of two *Exoneura* nests in a dead frond of the tree fern *Cyathea australis*, from the Dandenong Ranges (Victoria). The smaller bees are *Exoneura richardsoni*, the larger bees are *E. bicolor*. Note that nests of both species are simple burrows in the frond and the brood lie loose in the nest lumen.

by several factors:

(i) *Extended foraging period of Honey Bees*

Honeybees live in large hives in enclosed cavities, such as tree hollows, and maintain hive temperatures at fairly high and constant levels, approximately 36° C. This means that Honey Bees are active throughout most hours of the day, and can commence foraging very early in the morning. In contrast, native ground and stem-nesting bees cannot regulate nest temperature - adults only become active when the ambient temperature is warm enough to allow their flight muscles to operate efficiently. Many plant species replenish their nectar overnight; so that the early foraging tactics of Honey Bees may allow them to harvest this resource before native bees become active.

Maintaining a constant hive temperature also enables Honey Bee workers to venture out during the colder seasons. Because the activity of most native bees relies on ambient temperature one might not expect the winter activity of Honey Bees to have much impact. However, some native bee species are active during these colder times (eg. the reed nesting allodapine bee *Exoneura xanthoclypeata*, Tierney 1994), and it is possible that the ability to feed brood, or replenish individual energy levels, during times where resources are otherwise uncontested is critical to their life cycle. In such cases, introduction of a cold-weather adapted species could have major negative impacts.

(ii) *Recruitment of Honey Bee foragers to food sources*

On returning to the hive, worker Honey Bees are able to communicate the approximate direction, distance and kind of flowers that are available to the hive using dance language and odour cues. This means that when rich floral resources become available, Honey Bees are able to exploit them very rapidly and efficiently by recruiting hundreds or thousands of nestmates. The vast majority of native bee species live in small colonies and are unable to recruit other foragers, and, therefore, are unable to exploit newly arisen flower patches as rapidly as Honey Bees.

(iii) *Foraging distances covered by Honey Bees*

Honeybees have the ability to collect resources over extremely large distances. In the semi-arid area of Eyre Peninsula in South Australia one hive removed from a farmhouse contained mangrove honey, yet the nearest mangroves were over 20 kms away. One likely consequence of such ability is that Honey Bees may be more able to withstand local shortages in floral resources by exploiting distant resource patches. On a hot day, anyone who spills water on the ground in a semi-arid area where water is scarce will be aware of how efficient Honey Bees are at locating and exploiting restricted resources. Water is required to cool Honey Bee hives in hot weather and Honey Bees locate this scarce, and often distant, resource within hours of its appearance.

Empirical evidence for interactions between Honey Bees and native bees

Given the ubiquity of feral Honey Bees in non arid Australia and the potential for resource competition, it is surprising that comparatively little investigation of their impact has occurred. Three main studies have been carried out to date and we will briefly outline the results and discuss their consequences.

Pyke and Balzer (1985) were the first researchers to investigate the possible effects of Honey Bees on Australian native bees. Their approach largely involved correlating the abundance of native bees on flowers with the local abundance of Honey Bees. They found some evidence for a negative correlation, but the strength of their conclusions has been criticised for the indirect nature of this kind of study. Pyke and Balzer assumed that if Honey Bees adversely affected native bees, native bees might move away from, or otherwise decline in areas utilised by Honey Bees, leading to lower numbers. However, Paton (1993) has pointed out that in some cases the negative impacts of Honey Bees might act to increase the apparent abundance of native bees. For example, if fewer resources are available because of Honey Bees, native bees will need to forage more frequently or for longer periods to obtain the same amount of pollen and nectar. Such a reaction could actually increase the

apparent abundance of native bees in affected areas. Similarly, one could argue that if resources become more abundant, then native bee activity levels might decrease since increased foraging success would lower the amount of time required to provision brood cells. Pyke and Balzer's study must now be regarded as inconclusive, but it was pivotal in stimulating research into the general problem of Honey Bee impacts in Australia.

Sugden and Pyke (1991) used a more direct method to assess resource competition. Their study, in Nadgee Nature Reserve in south eastern N.S.W., experimentally investigated resource competition. Honeybees are mostly absent from this area, and hives were transported in to establish an experimental area where Honey Bee presence was artificially raised to a high level. They then monitored the number of nests of a common Australian allodapine bee, *Exoneura asimillima*, as well as rates of brood production and sex allocation. This approach avoided the problems that arose with Pyke and Balzer's study, but revealed additional problems for investigating competition. Their experimental design used only one experimental plot (although there were three control plots), so that local geographic variability within the Nadgee reserve could not be accurately gauged. A further problem arose in that a variety of factors influencing colony size of native bees could not be distinguished; eg. smaller colony sizes in an area could result from reduced resource levels, but could also result from early maturation of brood and subsequent dispersal from natal nests. Nevertheless, their findings did show that some brood production parameters for native bees differed between the experimental and control plots, but these did not unambiguously demonstrate negative interactions.

Schwarz, Gross, Kukuk and Hobbs (WWF-funded study, final report currently in preparation) took a similar approach to Sugden and Pyke in that Honey Bee density within natural areas was manipulated by transporting Honey Bees into specific areas. However, a larger number of replicate plots were used (a minimum of four experimental and four control plots) and experimental periods were divided into

specific parts of the life cycle of the native bee, *Exoneura bicolor*, ie brood rearing, overwintering, and periods of foundress dispersal. Also, two experimental manipulations were used: commercial-scale introduction of Honey Bees (approximately 100 commercial hives were placed in each site. These experiments were conducted with the aid of beekeepers who were utilising honeyflow conditions in the study site), and smaller scale introductions (six hives per site) designed to mimic a slight increase in the 'feral' Honey Bee population in the forest.

The final report from this study is not yet published, but should appear in mid 1997. Analyses indicated little or no evidence for resource competition. Indeed, the only significant trends that were found were *increased* levels of survival of native bees in some sites when Honey Bee density was elevated. That is, native bees survived better when Honey Bee levels were increased. This result seems counter-intuitive, but it may have revealed a previously unsuspected way in which Honey Bees impact on natural ecosystems. Most or all native bee species are subjected to predation by ants, spiders and other fauna. When a large number of Honey Bees are introduced into an area, the elevated density of bees may saturate the local predator population, reducing predation on native bees. In the short term, this might be beneficial for native bees, but in the longer term it may be negative by increasing predator levels. If commercial hives are removed at the end of honeyflow conditions, this could lead to native bees experiencing artificially elevated predator populations at a time when honeyflow conditions have ceased and food resources are restricted.

Why the apparent lack of negative impacts?

Whilst the possibility for negative impact of Honey Bees on native bees may seem likely, at present there is no strong evidence for such an effect in Australian ecosystems. Why is this so? We will now briefly consider two possible answers:

(i) *No resource competition between Honey Bees and native bees*

This could be the situation if, for example, floral communities contain an excess of pollen and nectar compared to that harvested by bees. An oversupply of nectar and pollen may have arisen if plant species compete with one another to attract a limited population of pollinators. This could lead to an 'arms race' involving nectar and pollen production with the end result being that plant communities produce more resources than can be harvested by floral feeders. A similar situation could arise if bee populations are constrained by predators or parasites, such that enemies of bees limit their population levels more so than food resources.

(ii) *Limited habitats and bee species have been studied*

The studies to date have utilised ecosystems where floral products were abundant. Sugden and Pyke's (1991) and Schwarz *et al.*'s (in prep) studies both utilised floristically rich subcoastal heathland, where pollen and nectar may be unusually abundant and hence lessen the likelihood of resource limitation. Also, the native bee species examined in these two studies are quite resilient to low food levels.

Both studies utilised allodapine bees which have the unusual habit among bees of rearing their brood progressively, and are able to withstand unusually long periods of food deprivation before larval mortality occurs (Michener 1974). It is possible that mass provisioning bees (and these comprise all native bees other than allodapines), which have more clearly limited brood rearing periods, may be more susceptible to short term decreases in floral resources. Furthermore, allodapines are long-tongued bees and highly polylectic, being able to forage from most flowers within a habitat. Most Australian native bees, however, are short-tongued and forage from a restricted range of plants (primarily myrtaceous species); these short-tongued bees may be less able to switch foraging strategies to avoid competition with Honey Bees.

Directions for future research

Previous studies have utilised habitats or subject species where resource competition may be less likely, or have employed methods which do not provide unambiguous results. For this reason we would argue that the jury is (or least should be) still out

regarding the possibility of negative impacts of Honey Bees. Future studies should take two directions: they need to investigate habitats which are not floristically rich or diverse; and they need to investigate native bee groups that may be susceptible to competition, such as short-tongued bees and other groups that are dependent on a restricted group of plants. These areas of research will be difficult to investigate because they do not lend themselves to the high level of monitoring and large sample sizes that are required by scientific studies. In addition to competition with native bees, Honey Bees may also compete with vertebrates for hollows to use as nest sites and this is another area for investigation.

Control of feral Honey Bee populations?

Even without any clear evidence to suggest that Honey Bees are having a negative impact on native bee fauna it is difficult to imagine, given so many other Australian examples of the effect of introduced species, that Honey Bees do not impact on our ecosystems. One very thorny problem that will require consideration, if negative impacts are demonstrated, is that of methods to reduce feral Honey Bee populations, especially in areas of high conservation status.

Feral Honey Bees are very widespread in non arid areas and are present whether 'honey flow' conditions occur or not. In times of floral scarcity, it may well be that low levels of Honey Bees have more negative impacts than when they are present in high densities during times of floral abundance. Controlling feral populations will be difficult because the method that is most likely to be cheap and effective, biological control, would have serious implications for the honey industry. A variety of diseases and invertebrate enemies of Honey Bees occur in other continents; they have been well studied and might be able to reduce feral population levels, but have been largely excluded from Australia to protect the honey industry. More costly control measures, such as baiting or selective destruction of hives, could be used to reduce feral populations in areas of high conservation value, but this would require substantial and on-going

financial commitment. In semi-arid and arid regions, one inexpensive method to control feral populations would be to remove artificial sources of free water. However, this would only be possible in areas free from commercial stock, eg. where dams are on land that has since been set aside for conservation. Destruction of such dams might also reduce the impact of feral goat and fox populations and also reduce the tethering effect on native vertebrates.

In conclusion, Honey Bees have become ubiquitous in Australia's ecosystems, however, their presence does not seem to have the commercially negative impacts of pests that affect agriculture and farming practice. Unfortunately, at this time we are not able to reliably gauge their impact on native ecosystems. Despite the difficulties associated with research focused on ecosystems and species where impacts may be more likely, such experimental studies should be the priority for further research.

Acknowledgements

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The Honey Bee Debate: a Critique of Scientific Studies of Honey Bees *Apis mellifera* and Their Alleged Impact on Australian Wildlife

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Abstract

Six factors - the nectar resource and use by Honey Bees, poor knowledge of the biology of native fauna, bee predation by birds, resource utilisation by commercial beehives on apiary sites, mutual exclusion of apiary sites where buffer zones exist and environment - are discussed in this paper which I believe could influence or cause the interactive effects between Honey Bees and wildlife which *appear* to have been demonstrated by published research results. The conclusion reached is that there is no conclusive proof that Honey Bees have a significant effect on wildlife and that any interaction which can be found could arguably be a normal reaction in a complex ecosystem that has its primary food source as nectar and pollen. After 170 years some form of equilibrium has probably been reached. (*The Victorian Naturalist* **114**, 1997, 13-22).

Introduction

Honey Bees in Australia

Australia is probably the most recent continent to be home to European Honey Bees *(Apis mellifera)*; most were brought here about 174 years ago (New South Wales in 1822, Anon. 1996; Western Australia in 1846, Smith 1964). At least one race, *Apis mellifera ligustica*, remains isolated in its pure form on Kangaroo Island, South Australia which is the only Honey Bee sanctuary declared by an Act of Parliament in Australia (Woodward 1993). However, the genetic purity of these bees has been questioned by Oldroyd *et al.* (1994). Many races of *A. mellifera* have been imported into Australia, the most recent have been from Russia.

The Honey Bee freely reproduces in the Australian environment and consequently few areas in Australia are now free of this exotic insect. In W.A., for example, feral Honey Bees have been recorded over the entire south-west land division and even as far north as the Hamersley Ranges (1,100 km from Perth) which is not far from the edge of the Great Sandy Desert.

Only two other species of European bees have entered Australia. The Bumble Bee, *Bombus terrestris* first discovered in 1992 and now well established in Tasmania, (Semmens *et al.* 1993) and the Leafcutter Bee *Megachile rotundata* of which 100,000 pupae were legally imported into South Australia in 1987-88, followed in 1996 by a proposal to import 5 million

pupae over three years (McDonald 1996). *Megachile rotundata* has, however, never established itself in Australia.

Two *Apis mellifera* subspecies *(A. m. yemenitica* and *sahariensis)* have adapted to hot dry climates in Africa, thus demonstrating that the species *A. mellifera* can adapt genetically to xerothermic environments (Ruttner 1986). Given that Africa and Australia have a similar range of climates and topography, the ecological differences which may have assisted the speciation of *A. mellifera* in Africa are likely to be the same as that in Australia.

It seems inevitable that feral Honey Bee populations in Australia will eventually become 'endemic' as taxonomically distinct Australian subspecies.

The European Honey Bee and the Australian environment

In Australia, the Honey Bee and its interaction with native wildlife has been the topic of debate for more than a decade. Numerous articles have been published about the negative effects that this introduced insect is alleged to have on native animal-plant communities, viz Douglas (1977), Schaffer *et al.* (1983), Matthews (1984), Pyke and Balzer (1985), Roubik *et al.* (1986), Hopper (1987), Taylor and Whelan (1988), Pyke (1990), Hussey and Wallace (1993) and Bailey (1994). Anderson (1989) and Paton (1990, 1995). An array of management plans have been suggested as a 'solution to the problem', but Paton says the impact is unlikely to be trivial.

A number of reviews of the debate have

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been published over the years (Donovan 1980; Bell 1987; Thorp 1987; Stace 1988; Wapshere 1988; Keith and Briggs 1989; Manning 1989) but Paton (1993), Seeman (1994), Paton (1995) and Sugden *et al.* (1996) are the latest studies on this subject.

In Europe, the debate is different. There, the Honey Bee *is* the native animal that needs protection. Exotic diseases, agricultural practices, pollution and local beekeepers using different races of *Apis mellifera* from other parts of Europe, all threaten the species or its subspecies (see Batra 1995).

Roubik and Buchmann (1984), Paton (1993) and Batra (1995) say the interactions between Honey Bees and native biota are complex and difficult to demonstrate scientifically. Unlike other alien feral animals in Australia such as rabbits, goats, pigs or cane toads which can physically damage and alter an environment or consume the native animal inhabitants, Honey Bees, both managed and feral, imbibe nectar from a resource pool that is freely available e.g *Eucalyptus*, and have few effects on the environment that are clearly visible and easily measurable to allow the debate to be resolved. For example, Sugden *et al.* (1996) reviewed 23 papers on Honey Bee - native bee competition and found 6 to be unclear and 17 conditional (or with assumptions) about the indication of resource competition. For six original authors who had stated that there was indication of resource competition, Sugden *et al.* (1996) overturned two to unclear status and four to conditional status. They defined 'unclear' as failure of experiment to demonstrate anything and 'conditional' as dependent on certain conditions and/or with assumptions.

It is interesting to note, however, that some researchers conclude they cannot state categorically that the data they obtained show that Honey Bees have a detrimental effect on native flora and fauna e.g. Schaffer *et al.* (1983) and Sugden and Pyke (1991). Other researchers have concluded that Honey Bees are either unlikely to have an impact (Bond and Brown 1979 for honeyeaters; Vaughton 1992 on reproductive success of *Banksia spinulosa)* or, have no significant effect (Sugden 1986 for native bees, Paton 1992 for birds, native bees and small mammals and Oldroyd *et al.* 1994 for Regent Parrots).

Despite these scientific findings, people caught up in the emotive and philosophical issues of this debate still choose to ignore these or are selective in their arguments. Where competition has been found to exist, some researchers actually deemed it to be automatically detrimental e.g. Pyke (1990) to native wildlife when the natural response of all animals is to compete for resources. Biological systems are dynamic and are adapting continuously to changes in the environment.

The lack of undeniable evidence of a detrimental effect has been a constant problem in the debate on Honey Bees and the environment. Land managers should have recognised that the references on which land agencies based draft plans for beekeeping on public lands were often of poor quality and devoid of scientific data. For instance, in Western Australia, many draft management reports for reserves and national parks have used the references of Douglas (1977), Scheltema (1981), Matthews (1984), and Pyke and Balzer (1985) to recommend restriction (Moore *et al.* 1983) or exclusion of beekeeping from reserves, and to make statements such as 'There is evidence to suggest Honey Bees can have a detrimental effect on native bees and vegetation' (Smith *et al.* 1988). The four references cited, however, are not from scientific journals and, apart from Pyke and Balzer (1985), are entirely based on the authors' personal opinions.

The 1985 report by Pyke and Balzer was the first scientific study of Honey Bees in the Australian environment. A critical evaluation of the report (Anon. *c.* 1987), however, showed fundamental errors in experimental design and also drew attention to the selective use of data to support recommendations on excluding beekeeping from national parks and reserves. Pyke and Balzer's own statements in their report, viz 'we have not obtained definitive evidence of competition between Honey Bees and native bees', and, 'The apiary of 60 hives in Royal National Park had no detectable effects on the densities of either honeybees or native bees in the surrounding area', do not support their reasoned recommendation of exclusion. The four references already mentioned were of little use in formulating land management policy at the time.

Nevertheless, the problem of whether

Honey Bees are detrimental to native wildlife has piqued the interest of a number of scientists, and further research has taken into account some of the faults of previous studies. For instance, Sugden *et al.* (1996) states that of the 23 papers they reviewed 'The most stringent analysis would reject most if not all of the studies as incomplete or flawed and, therefore, incapable of providing useful conclusions'. The improved techniques involve more careful attention to experimental design, carrying out research where commercial beekeeping is practiced or where there is high feral bee density, obtaining data over a number of seasons or years to smooth the seasonal variation of data, having a sound knowledge of the biology of the animal the Honey Bee is supposed to compete with in the environment, and a knowledge of the Honey Bee.

Six problem areas in Honey Bee studies

Where experiments are carried out, the data gathered could be influenced by six factors: the nectar resource and how Honey Bees and native fauna utilise it; the biology or ecology of the animals under study; bee predation by birds; the length of time commercial beehives are occupying apiary sites; the existence of Honey Bee-free "buffer zones" between formal apiary sites; and the environment. The lack of understanding of each of these issues is probably the main cause of experimental failure to provide conclusive proof of the effect that Honey Bees may, or may not have, on Australian wildlife, whether this effect is detrimental (as is commonly supposed), beneficial or neutral.

Most of the putative effects of Honey Bees on other fauna and flora concern resource competition (Wratt 1968; Bond and Brown 1979; Koeniger and Vorwohl 1979; Schaffer *et al.* 1983; Roubik and Buchmann 1984; Pyke and Balzer 1985; Roubik *et al.* 1986; Buys 1987; Wills *et al.* 1990; Paton 1993; Bailey 1994; Oldroyd *et al.* 1994). Others include disrupting the natural plant pollination systems (Taylor and Whelan 1988), effect on reproductive systems of native bees (Sugden and Pyke 1991) and increasing weed abundances through increased pollination (Butz Huryn and Moller 1995).

1. The nectar resource and its use by Honey Bees

Australian flora targeted by beekeepers (e.g. *Eucalyptus* spp. and *Banksia* spp.) produce copious amounts of nectar. This sugar-rich fluid has been correctly described as a plant survival mechanism to attract pollinators (Ford *et al.* 1979). Wild Honey Bees rapidly convert the surplus nectar collected into honey and when the nectar flow finishes, they start using the honey which they have carefully stored. Commercially managed Honey Bees, of course, are continually moved to other flowering areas by their owners to maximise honey production and to protect the stored honey resource for harvesting later. Nectar in oversupply or superabundance, the (feral) Honey Bees' ability to store nectar as honey and the temporary use of the nectar resource by beekeepers are all factors which make it difficult for researchers to measure any effect.

Nectar is a renewable resource and if removed from flowers on a daily basis, it is replaced each night in nearly all plants until the flower dies. For some plant species, sugar production is increased by nectar removal and for others it causes floral senescence and is often related to whether a plant is self-pollinated or requires out-crossing (Galetto and Bernardello 1993). Nectar that is not removed from flowers often drips onto the ground (e.g *Corymbia*, formerly *Eucalyptus*, *calophylla*), evaporates or may even ferment under certain environmental conditions. The sugar concentration in flowers can vary significantly during the day and over the flower season. Flowers on the leeward side of trees are known to contain more nectar than those on the windward side. The methodology of nectar measurement needs to be carefully planned in experiments.

Scientists, for example, would have to determine whether the behavioural patterns of animals under study undergo change towards the nectar resource with the passage of time. In one fascinating study in Costa Rica, Koptur (1994) researched the plant genus *Inga* and found that freshly secreted nectar was sucrose-dominant and over time changed to being hexose-rich; for some species of *Inga* there was a corre-

sponding shift in the pollinator fauna.

Honey Bees target nectar-rich sources and show a high degree of constancy. They are not, however, indiscriminate nectar- and pollen-collectors but can identify nectars according to their sucrose-glucose-fructose composition and sugar concentration. Hummingbirds are also able to distinguish between nectars and have a preference for sucrose over a hexose mixture over glucose over fructose, as Martinez del Rio (1990) has found. A study by Giurfa and Nunez (1992) found behavioural shifts of Honey Bees at different times of the day associated with different inflorescence stages. This switch to another developmental stage occurred without exhaustive exploitation of the available inflorescences of the previous stage. Honey Bees can also distinguish between the pollens of different cultivars of the same species (Jackson 1992).

Researchers need to be aware how fickle Honey Bees can be. Van der Moezel *et al.* (1987), for example, found that in one particular year Honey Bees had a strong forage preference for *Leucopogon conostephioides* and *L. striatus* and yet in the following year at the same site they switched their preferences to *Acacia stenoptera* despite the fact that flowers of both species of *Leucopogon* were still flowering in abundance.

Do researchers truly understand the complexities of Honey Bee social organisation and behaviour before embarking upon experiments that are equally complex? Do they know that Honey Bees will forage when temperatures are above 13^0C (Gary 1992), have a preference for specific sugars at certain concentrations, and prefer nectar-rich plants (Shuel 1992). Do they understand that feral bees (under managed conditions) store up to 22% less honey in hives than commercially managed bees (Manning 1994), or that many commercial beehives contain breeding stock that have the ability to produce 35% more honey than queen bees from other commercial beekeepers (Manning 1996)? In terms of nectar, these percentages equate to huge volume differences and would influence resource competition experiments. The effects of many less-than-appreciated facts of Honey Bee behaviour on a less-than-carefully-constructed research project could have far-reaching consequences as

far as the credibility of the researchers' conclusions are concerned.

2. Understanding the biology of native fauna

To research the relationship between Honey Bees and native nectarivores, study projects should be carried out over at least three years to take into account annual variations in various parameters such as standing crops of nectar and pollen, weather etc. Many experiments have been short term in duration e.g. two hours (Taylor and Whelan 1988), 115 hours (Pyke and Balzer 1985) with a few lasting 4 years or more (see Sugden *et al.* 1996).

Van der Moezel *et al.* (1987) and Sugden and Pyke (1991), for example, all had variation problems with two-year samples - the latter with unexplained forage preference changes of Honey Bees from one year to the next. Sudgen and Pyke also noted differences in micro-climate and native bee populations between control and experimental sites and possible sampling bias as their source of variation. Oldroyd *et al.* (1994) suggested that longer-term studies might be necessary to detect interactions between Honey Bees and native fauna and flora.

Most research projects in this discipline are measuring, for the first time, interactions between Honey Bees and native species or wildlife habitat. A danger in data interpretation is that specific biological and ecological requirements of native animals selected for study are from the outset poorly understood and could reflect something other than what was expected. Paton (1993) states that because of this problem the appropriate species for studying Honey Bee/native wildlife interactions have yet to be found. Therefore it can be reasonably assumed that any effects observed and measured *could* have been caused by environmental cues (e.g. moon cycle, season, time of day), or by peculiar behavioural and/or reproductive signals that naturally regulate the native animals' life cycles and *not* by the presence of Honey Bees. Fluctuating environmental factors must also influence the interaction being measured.

Complex behavioural relationships between native bees and their resource have been documented. In Cross (1992),

foraging preferences of a native bee *Trichocolletes* sp. on three sympatric species of legume (two *Dillwynia* sp. and a *Pultenaea* sp.) which exhibited subtle differences in floral morphology and rewards of nectar and pollen showed that *Trichocolletes* sp. displayed inconstant foraging and, as a consequence, **increased** the pool of resources in that particular habitat. Bernhardt and Walker (1984) also looked at three sympatric legume plant species *(Acacia)* and found the most frequent bee genera was *Lasioglossum* sp. and *Leioproctus* sp. They found that when flowering times of two *Acacia* sp. overlapped, bees selectively foraged on one species and this specialised (oligolectic) foraging altered to moderately generalist (polylectic) as the season changed from late winter to early summer. Over this period, the number of pollen genera found on a bee species tended to increase as the number of sympatric plants in flower increased and overlapped with the flowering period of each *Acacia* spp. Another good example worth reading is the complex patterns of competitive interaction between Ruby-throated hummingbirds and two species of *Bombus* on a single plant species (see Laverty and Plowright 1985).

Projects carried out over just one season can be vulnerable to behavioural changes of bees to their resource, such as those demonstrated for *Acacia* and *Inga* species (as examples), let alone trying to interpret this behaviour after *Apis mellifera* hives are brought into the experimental site.

3. Predation by birds

Some native bee species can form small colonies but most species are solitary (Batra 1984). Because they are solitary, predation by birds could severely reduce local populations. The scientist may not be aware if bird predation is affecting populations during the experiment, especially if measurements are taken periodically over a long time. For example, in spring each year Rainbow Bee-eaters *Merops ornatus* migrate from Indonesia to south-west of Western Australia in large numbers; their diet consists mainly of native insects including bees and dragonflies but they also take European Honey Bees. A similar species, *Merops apiaster*, has 29-42% of their diet made up of Honey Bees and only forage up to 200 m from

their nests - rarely up to 2,000 m (Kristin 1994). *Merops ornatus* has been known to have a severe impact on the bee population of commercial beehives in Australia (Girdler 1937, Goebel 1984). These hives, on average, contain 30,000-40,000 bees. Before 1846, Rainbow Bee-eaters in W.A. would have relied solely on native insects. Since the arrival of Honey Bees in W.A., the native bee and other insect populations are likely to have been buffered to some extent from the effects of bird predation as Honey Bees became a substitute food source. Many other birds are recorded as feeding on Honey Bees, viz Noisy Friarbird *Philemon corniculatus* and Woodswallows *Artamus* sp. (Goebel 1984), Magpies *Gymnorhina tibicen* (McDonald 1923, Kent 1923), Noisy Friarbird (Pile 1935), Dollarbird *Eurystomus orientalis* (Brewer 1935), Martin swallows [*sic* - probably *Cecropis* sp.] (Angas 1928), Red Wattlebirds *Anthochaera carunculata* (Mueller 1991) and Crows *Corvus* sp. *(pers. obs.)*. By inference, all these species must also eat native bees and insects. Collins and Briffa (1982) have shown that honeyeaters consume a wide range of insects, including Honey Bees. Hussey and Wallace (1993) state that honeyeaters feed insects, not nectar, to their young.

4. Commercial apiary site use

Commercially managed beehives occupy apiary sites for relatively brief annual periods or for sporadic periods that are often years apart In Western Australia, the average period of occupancy for all apiary sites for commercial beekeepers is 12 weeks (Manning 1992). This covers only part of the normal flowering period of plants being targeted by beekeepers, and normally straddles the peak flowering period.

Migration of beehives occurs at least six times a year in Western Australia (Hornitzky *et al.* 1991), so that beekeepers trying to maximise nectar flows could occupy sites for periods as short as nine weeks in some years. This leaves an even greater portion of the flowering period under-utilised by commercial apiarists.

An examination of the data in Manning (1992) shows that the proportion of use averages 54% (range 23-83%) for annual apiary sites (Fig. 1). These sites target coastal sandplain flora. That is, beekeepers
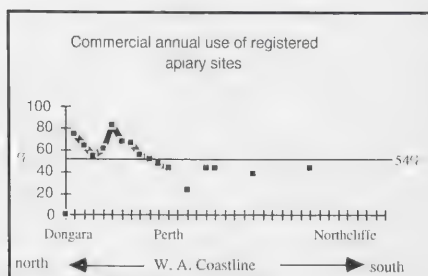
Fig. 1. Commercial annual use of registered apiary sites. The horizontal axis represents the W.A coastline that is divided into grids of approximately 68 000 ha (1:50 000 maps). The percentage use is derived from the average time (weeks) beehives are on site over the range of use, in weeks, for each grid. The figure shows that most activity of beekeepers is north of Perth.

Fig. 2. Commercial 2-year use of registered apiary sites. The horizontal axis represents the W.A. coastline that is divided into grids of approximately 68 000 ha (1:50 000 maps). The percentage use is derived from the average time (weeks) beehives are on site over the range of use, in weeks, for each grid. The figure shows that most activity of beekeepers is south of Perth.

who use their apiary sites annually will usually move to another site, leaving sites free of commercial Honey Bees for about 46% of the flowering period.

Even for Western Australian forest species, which are generally used every two years, the range and average use are similar to those apiary sites used annually (Fig. 2). Overall, commercial apiarists in Western Australia are only harvesting about 40% of the potential honey crop from an estimated 62% of available land controlled by the Department of Conservation and Land Management of Western Australia (Manning 1992, 1993).

If experiments were conducted to investigate the effects of commercial beekeeping practices on native animals, the short period during which beekeepers occupy apiary sites would make it difficult to measure the effect on the **complete** life cycle of any native animal. In the case of birds or marsupials it would be especially difficult because they are longer lived than insects.

5. *Mutual exclusion of apiary sites*

The topography of an area influences access to apiary sites so that, for most beekeeping areas, apiary sites are somewhat loosely arranged geographically. As a result, buffer zones that are relatively free of managed Honey Bees are formed between neighbouring commercial beekeeping sites.

A government land management agency usually regulates the distance between apiary sites. The minimum distance between sites in Western Australia is 3 km. Assuming then a radius of 1.5 km for each
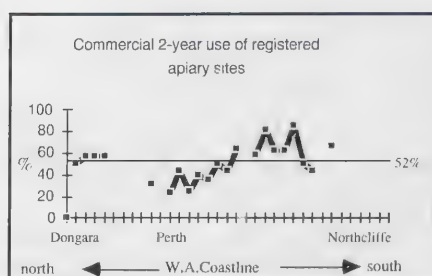
site, this gives the total area of each apiary site to be just over 700 ha. Based upon calculations by Manning (1992), the area, between all the officially sanctioned apiary sites - the buffer zones - represents about 1.05 million ha of commercially untapped nectar. Manning (1992) estimated this to exceed 116,000 tonnes of nectar available to wildlife in an average honey production year (assuming Honey Bees are only fully exploiting the nectar resources within the apiary area).

Honey Bees forage usually within a 1.5 km radius of the hive (Thorp 1987), although Sugden and Pyke (1991) give the slightly higher figure of 2,000 m. Other researchers have shown that 65% of bees leaving a beehive forage 500-800 m from the apiary and very few (4%) foraged between 1,500-2,500 m (Levchenko 1959). In a densely flowering crop such as sunflower, most of the bees foraged within 250-270 m of their apiary (Bitkolov 1961). It is difficult to relate the absolute percentages of the total forager population that are dispersing to various distances from their beehives, as much depends on apiary site density (and feral bee density), and the nutritional qualities and productivity of nectar and pollen sources. As mentioned before, commercial beekeepers target nectar flows which are nearly always very productive and this practice will confine Honey Bees to smaller forage ranges than those allocated by government agencies.

The nectar resources in the buffer zones and in the outer boundary areas of apiary sites are therefore likely to be under-

utilised. Having this variable gradient of nectar supply within the apiary site could clearly influence the results of research conducted in the area.

6. Environment

The environment can play a significant role in influencing Honey Bee experiments. The weather, such as freak wind storms could, for example, destroy flora a few kilometres away from a research plot and force more wildlife into the experimental area. Wildfire could have the same effect.

Rainfall and humidity can affect nectar production and will also affect the wildlife under study. Manning (1992, 1993) suggested that extreme summer and winter temperatures were the cause of bud-drop of *Eucalyptus marginata* and *C. calophylla* trees in Western Australia in 1991. The end result was a short term severe decrease in forest nectar production. The weather can also cause permanent changes to ecosystems gradually over time. Johnstone (1990) discovered that when 80-year-old flora and fauna records from an isolated area of W.A. were compared with those from a more recent survey, local extinction of some birds and plants had occurred. Johnstone suggested that tropical cyclones (and resultant floods) had caused changes in the mangrove-dominant area.

The influence of environment on Honey Bee research has been documented. Sugden and Pyke (1991) believed that several uncontrolled factors such as the differing microclimates between research and control plots had clouded some of their results. Similarly, Laverty and Plowright (1985) found that microhabitat differences and time of day had significant effects on their experiments.

Man's destructive influences on the environment are well documented. But in New Zealand, Donovan (1980) noted 'Most known nest sites of the majority of (native bee) species have been made by the activities of man'. He sights roadside cuttings or earth bared by machinery as frequently harbouring bee nests. In Australia, most national parks and reserves have firebreaks and if this bare ground has the same effective habitat use as it does in New Zealand, then experiments will be influenced.

The environment below the ground for many species of solitary bees creates many hazards. Solitary bees nest for nearly a year in this environment and are vulnerable when soil moisture levels are high or, to attack from microorganisms such as bacteria, yeasts, nematodes and particularly fungi. In the United States of America, Batra (1984) found adults and pupae of solitary bees are attacked by at least 124 species of fungi with some species of bee losing half their brood annually to fungal attack. Fungi caused some mortality to native bee species in New Zealand (Donovan 1980).

Conclusion

More factors could influence research results than the six I have mentioned in this paper. Others such as the influence of pre-dawn consumption of nectar by ants has not been measured in Australian research, but in two overseas studies, ants consumed 85% (Schaffer *et al.* 1983) and 42% (Buys 1987) of the nightly accumulation of nectar which suggests they may be having a large influence on measurements taken during the day (most experiments). Another important influence would be genotypic variability of Honey Bees, especially if you are using commercial hives in an experiment or only a few hives (as Taylor and Whelan (1988) did). Guzman-Novoa and Gary (1993) showed that there was significant variation between different stocks of Honey Bees in number of foraging trips, number of pollen foraging trips, round-trip time, age at first foraging flight, length of foraging life, survivorship, nectar load volume and nectar sugar concentration. Other influences include general forest and sandplain heath plant health (effects of fungus, water table, salinity and insect attack), plant age (e.g. four-year studies will have plants that are maturing throughout the experiment, and nectar volumes will increase as a consequence), plant genetics (e.g. Paton and Turner (1985) found that 3% of *Banksia ericifolia* developed follicles under natural conditions and that this was limited by resources and not by pollinators) and pollution (e.g. pollen can easily be contaminated with heavy metals which could affect fauna being studied).

However, I suggest that the six factors I have discussed are those which are likely to have the most impact on any research conducted on Honey Bees in the

Australian environment. Nevertheless, there is one other factor that is seemingly never touched upon, and that is the effect of the observation and measurement processes upon the behaviour of the animals being observed and how well the data is interpreted. Monitoring the effects of human intrusion and taking them into consideration when interpreting data is an important issue in ecological-biological research. It is a matter for some concern that the methodology and discussion of many published research projects do not take this particular potential problem into account. In the case of interpreting skills, some researchers like Westerkamp and Paul (1993) have proposed that a plant they carefully examined in detail was fly-pollinated but in the following year Bruneau and Anderson (1994) showed that it was frequently triploid and the seed sterile and that the only legitimate pollinators were Megachilid bees. Vaughton (1992) cautions against using morphological traits to predict pollinators.

In many research papers where 'resource competition' between Honey Bees and native Australian wildlife is inferred or demonstrated, the effect is commonly associated with the descriptive terms 'negative' or 'deleterious'. Pyke (1990) has possibly been the most vocal in using these terms despite his research into honeyeater-resource relationships. Law (1994) summarised four of Pyke's papers stating 'Temporal variations in honeyeater density near Sydney were neither related to nectar production nor biomass of flying insects. Experimental removal of flowers in this study area did not affect the density of nesting honeyeaters nor did experimental supplementation of nectar lengthen the nesting season...Clearly, food is not a limiting resource for all populations of nectarivores'. It is my belief that such use of these terms in the debate are premature, in that the research projects have not run long enough to provide a fair assessment of the long-term effects on life cycles. In fact some of the previous study areas could be revisited at a later date to determine whether there have been changes.

Indications from studies of resource competition between **native** species of bees (Koeniger and Vorwohl 1979) show that three *Apis* species and one *Trigona* species

co-existed together without disastrous competition and the smaller bee *(Trigona)* with its limited flight range (limited resource area) was compensated by more aggressive behaviour. A similar behavioural mediated response was found between native Hummingbirds and hawkmoths in Carpenter's study (1979) but not with *Xylocopa* bees also present. In an interesting study in the Galapagos Islands by Schluter (1986) of a single native species of bee *(Xylocopa darwinii)*, birds (finch sp.) and the nectar resource on several islands showed evidence of character displacement i.e. 'the use of flower nectar by finches on the Galapagos Islands may have been influenced by the presence or absence of bees, and that the presence or absence of bees may have influenced finch body size as a consequence'. Schluter showed that relatively high levels of nectar consumption by finches where bees were absent was associated with small finch size. An equilibrium has developed over time in both of these examples above to allow all these species to co-exist. In the 170 years since Honey Bees have been brought into Australia some form of equilibrium may have already been reached and is another reason why it has been difficult to conclusively report a significant impact of the Honey Bee upon the environment it now inhabits and utilises. Donovan's (1980) analysis of the effect of introducing **eight** bee species to New Zealand viz: *Apis mellifera, Bombus hortoum, B. ruderatus, B. terrestris, B. subterraneus, Nomia melanderi, Megachile rotundata* and *Peponapis pruinosa* indicated the native bee species 'enjoying considerable competitive success'.

I conclude that most research to date has failed to prove categorically that European Honey Bees are having a significant impact on Australian wildlife. On the contrary, several researchers are on record as having found the case against the Honey Bee 'not proven'.

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Honey Bees *Apis mellifera* and the Disruption of Plant-pollinator Systems in Australia

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Abstract

Honey Bees *Apis mellifera* visit the flowers of a wide variety of Australian plants harvesting nectar, and pollen. Depending on the plant species they may consume 80-90% of the floral resources, displace native pollinators and alter rates of pollination. These interactions are illustrated for several predominantly bird-pollinated plants. For Scarlet Bottlebrush *Callistemon rugulosus*, seed production decreased when Honey Bees displaced birds from flowers, and the removal of pollen from the flowers of Common Correa *Correa reflexa* by Honey Bees reduced the quantities of pollen subsequently dispersed by birds. In Ngarkat Conservation Park natural rates of seed production by Desert Banksia *Banksia ornata* were severely pollinator limited. When Honey Bees were introduced to this reserve seed production for *Banksia ornata* was enhanced. These studies illustrate the dilemma in managing Honey Bees in areas set aside for conservation in that some plants and animals are likely to suffer if Honey Bees remain in a reserve while others are likely to suffer if Honey Bees are excluded. (*The Victorian Naturalist* **114**, 1997,23-29)

Introduction

Australian environments have been drastically altered over the last 200 years. Extensive areas of native vegetation have been cleared for agriculture, and areas that have not been cleared have often been selectively logged or grazed by a suite of introduced herbivores including sheep, cattle, rabbits and goats. This fragmentation and degradation of natural habitats has had a profound effect on Australian wildlife and endemic ecological processes. Changes in water regimes (e.g. damming of streams), water tables and in the frequency and intensity of fires, as well as the depredations of introduced foxes and cats have further compromised these natural systems.

Plants and their pollinators are particularly vulnerable to changes, since changes in either the plants or the pollinators usually means that the other member of the partnership also suffers (Ford 1986; Rathcke and Jules 1993). Australian plants and their pollinators have also had to contend with Honey Bees during this period of rapid change. Honey Bees *Apis mellifera* were introduced to Australia in the 1820s and both feral and managed populations of Honey Bees are now widespread in Australia and prominent in many areas set aside for conservation (Paton 1996). Land managers in Australia are left in a dilemma about whether Honey Bees should or should not be excluded from conservation areas. Their dilemma reflects a lack of

information on how plants and animals are affected by Honey Bees. In this paper I briefly outline how Honey Bees may affect the pollination of Australian plants and discuss the contentious issue of management.

Honey Bees and the pollination of Australian plants

Honey Bees could alter the pollination rates of Australian plants in several ways. They could:

a) add to the pollination services provided by native fauna leading to increases in seed production;

b) displace native pollinators and not provide comparable pollination services leading to reductions in seed production;

c) alter the behaviour of native pollinators leading to native fauna providing different pollination services that in turn lead to changes in seed production; and/or

d) remove pollen so that that native pollinators (even if not reduced in numbers or altered in behaviour) transfer less pollen to flowers than they would if Honey Bees were absent, again reducing seed production.

These effects can be illustrated by considering three examples involving plants that are primarily bird-pollinated: Scarlet Bottlebrush *Callistemon rugulosus*; Common Correa *Correa reflexa;* and Desert Banksia *Banksia ornata*.

Scarlet Bottlebrush *Callistemon rugulosus* is largely self-incompatible and needs cross-pollination to set substantial quantities of

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fruit (Paton 1993). For example, only 11% of flowers bagged to exclude all visitors set fruit following self-pollination while 45% set fruit following cross-pollination (Paton 1993). Thus to be effective, pollinators must regularly contact the reproductive parts of the flowers and move frequently between plants.

New Holland Honeyeaters *Phylidonyris novaehollandiae* and introduced Honey Bees were the predominant visitors to the flowers of this plant at Scott Conservation Park near Goolwa, South Australia and Paton (1993) showed that, as the numbers of Honey Bees using the flowers of *Callistemon* increased, the frequency with which New Holland Honeyeaters visited flowers decreased. Honey Bees and Honeyeaters, however, differed in the frequency with which they struck stigmatic surfaces and moved between plants. For example, Honey Bees only struck the stigma on 4.4% of visits to flowers when harvesting nectar and 16.7% when harvesting pollen. In comparison, New Holland Honeyeaters contacted the stigma of the flower being probed on at least 50% of occasions and because of their larger size also frequently contacted stigmas of flowers adjacent to the one being probed. Honeyeaters also moved between plants more frequently than Honey Bees. In areas where individual *Callistemon* plants were widely spaced (>3m apart) individual New Holland Honeyeaters moved more than 70 times between plants during 10 hours of observation. Most of the birds studied were territorial and, although their foraging was restricted to their territories, these usually included more than one plant with 80% of territories having at least 2 and up to 17 *Callistemon* plants. As a consequence pollen would have been dispersed extensively between these plants. In comparison, Honey Bees failed to make any interplant movements between adjacent plants in 9.9 hours of tracking individual Honey Bees in the same area. During that time, individual Honey Bees were observed probing over 4,600 flowers with most of the individually-marked bees foraging repeatedly at the same flowers within the same section of a single shrub and repeating this over several days at least. Given these differences in foraging behaviour,

Honeyeaters are more likely to effect cross-pollination than Honey Bees. Thus when Honey Bees displace Honeyeaters from *Callistemon* flowers, levels of cross-pollination should decline and, if seed production is limited by pollinators, then this should lead to reduced seed production.

Rates of fruit production for *C. rugulosus* varied with the numbers of birds and bees working the flowers. First, the numbers of flowers that set fruit inside wire mesh cages, which excluded birds, increased as the numbers of bees increased indicating that Honey Bees could pollinate *Callistemon* flowers (Table 1). However, the rates at which caged flowers set fruit (7-17%) were similar to rates achieved following self-pollination (11%) and well below those achieved after cross pollination (45%, Paton 1993). The low fruit production at caged flowers was therefore consistent with Honey Bees effecting little cross pollination for this population of *Callistemon*. Fruit production at flowers exposed to both birds and bees, however, was significantly higher than that for caged flowers (Paton 1993, χ^2 tests, p's < 0.001, Table 1) indicating that birds provided important pollination services to the plant. However, this fruit production declined significantly from 35% to 23% as the numbers of Honey Bees using the flowers increased and visits by Honeyeaters decreased (Paton 1993, $\chi^2 = 38.0$, d.f. = 2, p <0.001). Thus displacement of pollinating birds by less effective Honey Bees

Table 1. Fruit production by *Callistemon rugulosus* inside and outside wire mesh cages at three levels of honeybee activity. The wire mesh cages excluded birds but did not alter the rates at which Honey Bees visited flowers. Sample sizes range from 735 to 2662 flowers. Fruit production at caged flowers exposed to Honey Bees and birds declined significantly with increases in honeybee activity ($\chi^2 = 38.0$, d.f. = 2, p <0.001). For further details see Paton (1993, 1996).
Key: A = Level of honeybee activity; B = % flowers setting fruit inside wire cages (Honey Bees only); C = % flowers setting fruit outside wire cages (Honey Bees and birds).

A	B	C
low	6.7	35.1
medium	15.3	27.9
high	17.1	22.6

reduced fruit production for this population of *Callistemon*.

In addition to reducing the quantity of fruit being produced, extensive use of *Callistemon* by Honey Bees may also lead to differences in the genetic composition of the seeds being produced. Since Honey Bees largely restricted their foraging to single plants many of the seeds produced when Honey Bees were abundant are likely to be selfed. Such seeds are likely to be less diverse, genetically, than seeds produced following cross-pollination. In other myrtaceous plants, selfed seeds have been found to be less viable than seeds produced following cross-pollination: fewer selfed seeds germinate and those that do often grow more slowly and have higher rates of mortality than seedlings that germinate from cross-pollinated seeds (e.g. Moncur and Kleinschmidt 1992).

The influence of Honey Bees on the viability and genetic diversity of seed crops in these and other plants still needs to be measured but the relationship is likely to be more complex than simply changes in the proportion of seeds that are selfed. For example, in the case of *C. rugulosus*, not only are there reductions in the frequency with which birds visit flowers when Honey Bees increase, but there are also other changes in the behaviour of the birds that could influence the genetic diversity of seed crops. When the numbers of Honey Bees increased, dominant New Holland Honeyeaters increased the sizes of their territories by excluding subordinate birds from adjacent territories (Paton 1993). The territories of these dominant birds were approximately twice the size of the territories they held when Honey Bees were scarce and contained about twice as many *Callistemon* plants. As a result of holding larger territories, these dominant birds should transfer pollen between a greater number of individual plants which should lead to increased diversity in cross-pollination. This might partially compensate for any increased rates of self-pollination being effected by Honey Bees. Genetic analysis of seed crops and testing of seed viability are still required to determine if there are further changes in the reproductive performance of *Callistemon* in the presence and absence of Honey Bees. At present, however, there is strong evidence that the quantity of seeds produced is reduced when Honey Bees visit the flowers.

Honey Bees can also alter rates of pollination by removing pollen from flowers, so reducing the amounts of pollen being transferred by legitimate pollinators. The best example to illustrate this is another bird-pollinated plant, Common Correa *Correa reflexa*. In Flinders Chase National Park, the flowers of *C. reflexa* are visited by both Honeyeaters and Honey Bees. *Correa reflexa* is protandrous and releases pollen from its anthers before the stigma is receptive. Honey Bees primarily harvested pollen from this species and consequently visited recently-opened flowers that were laden with pollen and rarely visited older flowers that were in the female phase and ready to receive pollen. Honeyeaters, on the other hand, harvested nectar from all the floral stages. Because Honey Bees preferred male flowers, they only pollinated the occasional *Correa* flower and were not as effective as birds which visited all floral stages. Unlike the *Callistemon rugulosus* example above, changes in the numbers of Honey Bees harvesting pollen from *Correa reflexa* flowers had no effect on the numbers and behaviour of birds using *C. reflexa*. This is not unexpected since the two taxa were harvesting different floral resources. So in this case Honey Bees did not displace birds from the plant and so there is no reason to expect Honey Bees to affect the plant's reproduction.

Field trials, however, revealed an unexpected result. Despite frequent visits to flowers by both birds and Honey Bees this population of *C. reflexa* was pollinator limited in that the quantity of fruit produced could be increased by dusting the stigmas of flowers with cross pollen. Such a result was inconsistent with known rates of visitation to flowers where the flowers of *C. reflexa* were visited on average 5-10 times by birds during their life. Based on measured rates of pollen transfer this rate of visitation should have been sufficient to guarantee that most flowers were pollinated. For example, Paton (1991) showed that in an aviary the probability of a honeyeater transferring pollen from one intact pollen-bearing *Correa* flower to the stigma of another on any one visit was around 40%.

Given this the probability that a flower would not be pollinated after seven visits from a bird would be just 3% (0.6^7). So what factors might lead to the pollination services by birds being inadequate for this plant? One possibility is that Honey Bees in removing pollen may reduce the quantities of pollen subsequently transferred by birds, so that, although the visitation rates might be adequate, the quantities of pollen being transferred might be inadequate for maximum seed production.

Observations at flowering plants revealed that visits to flowers by Honey Bees often outnumbered those by birds (e.g. Paton 1990,1993,1996) and that Honey Bees were often the first to visit recently-opened flowers, dislodging 87% of the pollen on their first visit (Paton 1993). Furthermore, on many occasions recently-opened flowers were visited several times by Honey Bees before any visits by birds so that little pollen remained when the flower was first visited by a bird. At times Honey Bees even chewed undehisced (unopened) anthers to rob pollen from flowers that were just opening.

Paton (1993) assessed the likely impact of this pollen loss on subsequent pollination by birds with a series of simple aviary trials. Captive Eastern Spinebills *Acanthorhynchus tenuirostris* were presented with eleven *C. reflexa* flowers: a source flower that supplied pollen and ten sink flowers that received pollen. Sink flowers had been emasculated before the anthers dehisced and so contained no pollen. Thus, any pollen that these flowers received during trials must have come from the source flower. The ratio of source flowers to sink flowers in these trials approximates the natural ratio. The flowers of *C. reflexa* live for about nine days. Consequently one flower in nine would be expected to have released pollen in the last 24 hours. In each trial, captive Honeyeaters were allowed to visit each of the flowers between five and ten times, similar to the frequency with which birds visited *Correa* flowers in the wild (Paton 1990, 1993, 1996, and *unpubl. data*). All flowers were then retrieved and the amount of pollen deposited on the stigma of each flower counted under a microscope. The amount of pollen initially present at the

source flower was then varied and any differences in pollen receipt by the sink flowers measured. To vary the amount of pollen at source flowers and mimic pollen losses due to bee visits, up to seven of the eight anthers were removed. When pollen was removed from source flowers, significantly fewer sink flowers received pollen, and the total number of grains landing on their stigmas was also significantly reduced (Paton 1993, Table 2, analysis of variance, F = 7.9, d.f. = 2,37, p <0.001 in both cases). These data suggest that the numbers of flowers pollinated by the birds could easily be halved and the amount of pollen transferred reduced to one-sixth when Honey Bees removed about 90% of the pollen (as they were found to do, e.g. Paton 1990, 1993, 1996). Field trials are now required to determine if seed production for this plant is reduced in areas stocked with Honey Bees, but the aviary data clearly illustrate the potential for Honey Bees to have a negative effect on pollination rates simply by removing pollen.

These studies showing potentially negative effects of Honey Bees on the seed production of Australian plants need to be balanced against other studies where Honey Bees have been found to increase rates of pollination.

Table 2. Influence of pollen availability at source flowers on subsequent dispersal of pollen to sink flowers by captive Eastern Spinebills visiting *Correa reflexa* flowers. Note that source flowers with 1 intact anther (instead of 8) have had 87% of their pollen removed, which is the average quantity of pollen removed by Honey Bees on their first visit to a flower. With 87% of the pollen removed only 25% of sink flowers received pollen and those flowers only received an average of 5.8 pollen grains each. More flowers were pollinated and the quantities of pollen deposited were significantly higher when all the pollen was available (analysis of variance, F = 7.9, d.f. = 2, 37, p <0.001 in both cases). For further details see Paton (1993, 1996). Values are means ± s.e.
Key: A = No. of intact anthers on source; B = No. of trials; C = No. of probes into sink flowers; D = No. of sink flowers receiving pollen; E = Total number of pollen grains deposited on the ten sink flowers

A	B	C	D	E
8	15	7.3 ± 1.0	6.2 ± 0.7	89.6 ± 14.0
4	12	7.9 ± 1.0	5.4 ± 0.7	51.8 ± 19.1
1	13	6.9 ± 0.7	2.5 ± 0.7	14.6 ± 4.5

Ngarkat Conservation Park is a large reserve in southeastern South Australia and an important over-wintering site for commercial apiarists. Desert Banksia *Banksia ornata* is the main floral resource exploited by beekeepers in this reserve. Assessments of resource use showed that native pollinators were unable to fully exploit the floral resources being produced by *B. ornata* in this reserve during winter and unable to pollinate sufficient flowers to maximise seed production (Paton 1995, 1996). When additional cross pollen was added to *Banksia* flowers, seed production was enhanced, indicating that native pollinators were insufficient. Although Honey Bees depressed food availability, the level of depression was not sufficient to affect the abundances of native fauna in these heathlands, with the numbers of Honeyeaters, small native mammals and various flower-inhabiting invertebrates (ants, native bees, beetles) being similar at sites that were and were not stocked with hives of Honey Bees (Paton 1995, 1996). For example, the numbers of Honeyeaters at sites stocked and not stocked with Honey Bees ranged from 2.2-2.9 and from 2.3-2.9 Honeyeaters per hectare respectively over three years (Paton 1995, 1996). The abundances of other fauna, however, were very low, with ants being observed at only 4.2% and 4.7% of 25,465 and 54,810 flowering inflorescences examined over three seasons (1990, 1992, 1993) in areas stocked and not stocked with Honey Bees respectively. Adult Staphylinid Beetles were recorded at only 0.29% and 0.60%, native bees at 0.50% and 0.26%, and scats of Silky Mice *Pseudomys apodemoides* or Pygmy Possums *Cercartetus* spp. at 4.7% and 6.1% of these inflorescences respectively. Seed production by *B. ornata*, however, was significantly greater at sites stocked with Honey Bees than at sites not stocked with Honey Bees in each of three years (analyses of variance, p's < 0.001; Paton 1995, 1996). At sites without Honey Bees seed production ranged from 4-7 seeds per inflorescence, while at sites stocked with Honey Bees seed production ranged from 8-11 seeds per inflorescence.

Although these figures show that Honey Bees enhanced the seed production of *B. ornata* they do not, and cannot, be used to infer that Honey Bees were better pollinators than native fauna. The primary reason for the poor reproductive performance by *B. ornata* in Ngarkat Conservation Park appears to be insufficient native fauna, particularly Honeyeaters, not ineffective pollination by those that were present. In other *B. ornata* heathlands closer to the coasts of South Australia, densities of Honeyeaters ranged from 6-22.5 Honeyeaters per hectare, two to eight times the density recorded at Ngarkat (Paton 1995, 1996). One reason why there might be relatively few birds in Ngarkat during winter when *B. ornata* flowers is because this area produces few suitable flowers for Honeyeaters during summer and autumn. As a result many of the Honeyeaters that use the park in winter must leave the park for summer and autumn. The areas that are likely to produce suitable resources for these birds during summer and autumn are the more mesic coastal and woodland areas of south-eastern South Australia. These areas, however, have been disproportionately cleared for agriculture compared to the drier sandy areas like Ngarkat that are least suited to agriculture. As a result, many of the Honeyeaters that leave Ngarkat may not be able to find sufficient food during summer and autumn and so perish. Thus, the low availability of nectar sources during summer and autumn may place limits on the population sizes of Honeyeaters in the region as a whole. If so, then the numbers of Honeyeaters that can return to the drier heathland habitats of Ngarkat for winter will be reduced and often insufficient to consume all of the winter resources. If this scenario is correct, then the placement of Honey Bees in this reserve during winter may help to counter shortages of native pollinators that may have resulted from perturbations in other areas.

The management implications of enhanced seed production for *B. ornata* in areas stocked with Honey Bees at Ngarkat Conservation Park, however, are complex, since natural rates of seed production prior to any habitat clearance are unknown. If seed production is naturally limited by pollinators, then allowing apiarists to have continued access to *B. ornata* in Ngarkat may lead to this *Banksia* becoming more

prominent in these heathland communities in future generations, perhaps to the detriment of other plants. If, however, the poor rates of seed production are due to reductions in densities of native pollinators then excluding apiarists from this reserve may facilitate the decline of *B. ornata* in future generations.

Management of Honey Bees in the Australian environment

Some care is required in managing Honey Bees in areas set aside for conservation in Australia. At present there are only limited data on which to base management decisions. As far as the plants are concerned the data show that seed production by selected native plants can be reduced in some cases and enhanced in others, but current studies do not consider whether these shifts in reproductive effort threaten the long term existence of specific plants. Perhaps the poor seed production by *Banksia ornata* in Ngarkat Conservation Park is still more than adequate for the maintenance of the *Banksia* population and so the additional pollination services provided by Honey Bees are not needed. But if seed production is not adequate then the exclusion of Honey Bees from this reserve could be detrimental. Similarly reductions in seed production for *Callistemon rugulosus* when Honey Bees were present may be of little consequence if more than enough seeds are still being produced to maintain the current populations. However, if they are not setting sufficient seed then failing to exclude Honey Bees from reserves could be detrimental to *C. rugulosus*. Thus the conservation benefits that might accrue by allowing Honey Bees to remain in an area versus excluding them are less than clear.

These examples are unlikely to be isolated cases, since Honey Bees are prominent at the flowers of many Australian plants. For example, Paton (1996) listed just the genera of plants whose flowers were visited by Honey Bees. More than 200 genera were involved, including species pollinated by wind, insects and/or vertebrates. In woodland and heathland areas Honey Bees have been recorded visiting the flowers of more than a third of the plant species living in an area (Wills *et al.*1990, Paton 1993). Furthermore, for many of the plants

Honey Bees were the most frequent (and sometimes only) floral visitors and consumed significant amounts of nectar and/or pollen, as much as 80-90% for some species (Paton 1990, 1993, 1996). Given this, there are likely to be many other cases where populations of Australian flora and fauna will be influenced in some way by the presence of Honey Bees. A substantial increase in research effort is required to document even a small proportion of these, and even after this research has been completed management would still involve making decisions on which native plants and animals were to be favoured in which areas.

Clearly the resources, both funds and people to tackle these deficiencies and implement and monitor outcomes of management actions over the Australian environment, are not available. Some strategy is therefore needed to focus research and management actions in key areas. Given that we are not sure about the outcomes of excluding or permitting Honey Bees to remain in areas, one management strategy might be to manage the environment in such a way that within a region or bioregion a minimum proportion of each habitat type is maintained free of Honey Bees. If Honey Bees are present in part or all of the remainder then those Honey Bees can continue to remain. This then protects any systems that might now depend on Honey Bees for continued existence, at least in some parts of a region. This approach provides an opportunity of salvaging systems and maintaining biodiversity which might not otherwise be possible if Honey Bees were managed in such a way that they were either present or absent from the entire habitat.

Those areas that need to be tackled first will be those regions or habitats where Honey Bees are more widely and consistently distributed. At present we lack much of the basic information to select these locations and so some of the initial research should focus on accurately documenting the distribution and abundance of both feral and managed populations of Honey Bees. There is some qualitative information available that suggests certain woodland habitats in southern Australia may have widespread and extensive popu-

lations of feral Honey Bees, as well as being exposed to regular use by apiarists (Paton 1996), so these areas should be surveyed first. Those regions, or habitats within a region, where Honey Bees are found to be most widespread, should be given priority for management. That management should consist of:

(1) reducing the area of habitat exposed to Honey Bees by removing feral colonies and implementing exclusion zones for managed hives from the selected areas as well;

(2) measuring the responses of native flora and fauna to this removal program; and

(3) adjusting the management actions based on measured responses.

A further challenge in managing Honey Bees in Australia is the need to consider the requirements of the honeybee industry since major changes in access to floral resources of Australian plants could have implications for a range of other horticultural industries that depend on Honey Bees for pollination in Australia. Whatever management actions are implemented, they need to be developed in collaboration with the honeybee industry. One advantage of the strategy outlined above is that it acknowledges that we have inadequate information on our natural systems and inadequate information on the impacts of Honey Bees on them. Instead of management actions depending on limited evidence, the aim is to secure at least some honeybee-free areas within each region of the continent irrespective of any impact or not. In this way if Honey Bees are detrimental to natural systems then there will be at least some places within each region or habitat type where natural processes may continue to exist and evolve in the absence of Honey Bees. Although there may be considerable debate on the proportion or amount of each habitat type that needs to be maintained free of Honey Bees in each region, such an approach should be palatable to both conservationists and apiculturists.

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New Perspectives on the Ecology of Lake Mountain (ii): Significant Ecological Communities and Species

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Introduction

Significant ecological communities and species which have a restricted biogeographic range are in decline or are vulnerable to threats. Such sites of high conservation significance occur on the Lake Mountain plateau and include the communities and species highlighted below. The transitional communities and Leadbeater's Possum habitat in sub-alpine woodland were described in Part 1 (*The Victorian Naturalist* 1995, **112**, 112-115).

Within the Echo Flat-Long Heath area, five plant taxa are recognised as having state or national significance and 33 have regional significance. Without exception, all 38 plant species are of regional or state significance because they are restricted to alpine or sub-alpine environments and are at their geographic limit within the region or the state. In particular, the Victorian endemic, Baw Baw Berry *Wittsteinia vacciniacea* is the only member in southeastern Australia of the Gondwanic family, Alseuosmiaceae and thus has special biogeographic and evolutionary significance (Table 1).

The most significant community at Lake Mountain is the wet sub-alpine heathland of the Echo Flat-Long Heath area (Fig. 1). It also supports the highest density of small mammals and all the amphibians in the area (Jelinek and Belcher, 1994) as well as a high diversity of aquatic macroinvertebrates (Doeg *et al*, 1994).

Previous studies at Lake Mountain include an assessment of the dynamics of the wet heath at Echo Flat by Ashton and Hargreaves (1983). Reports of excursions to Lake Mountain by the Field Naturalists Club of Victoria over many years describe other aspects of the area's ecology and they also provide an important historical perspective. These include Morris (1929),

Willis (1948), Garnet (1948, 1949), Smith (1979) and Calder (1993).

This paper highlights significant ecological communities and species recorded during an assessment of environmental impacts of two proposed cross-country ski trails at Lake Mountain in December 1993 (CNR 1994). A special feature of the flora and fauna surveys was the inclusion of bryophytes, macrolichens, fish and aquatic macroinvertebrates in addition to observa-

Table 1. Significant Plant Taxa.

A. Taxa of State or National Significance
Baeckea, Mountain, *Baeckea utilis* var. *latifolia*
Baw Baw Berry, *Wittsteinia vacciniacea*
Daisy, Baw Baw, *Brachyscome obovata*
Lilac Berry, *Trochocarpa clarkei*
Tuft-rush, *Oreobolus oxycarpus* subsp. *oxycarpus*

B. Taxa of Regional Significance
Astelia, Silver *Astelia alpina* var. *novae-hollandiae*
Beard-heath, Mountain *Leucopogon hookeri*
Bitter-cress, Lilac *Cardamine lilacina*
Bossiaea, Leafy *Bossiaea foliosa*
Bottlebrush, Alpine *Callistemon pityoides*
Bristle-grass *Trisetum spicatum* subsp. *australiense*
Buttercup, Strawberry *Ranunculus collinus*
Buttercup, Subalpine *Ranunculus scapiger*
Club-rush, New Zealand *Isolepis aucklandica*
Cudweed *Euchiton fordianus*
Everlasting, Cascade *Ozothamnus secundiflorus*
Filmy Fern, Alpine *Hymenophyllum peltatum*
Fleabane, Violet *Erigeron pappocromus*
Grevillea, Royal *Grevillea victoriae*
Heath, Snow *Epacris petrophila*
Holy Grass, Sweet *Hierochloe redolens*
Hook-sedge, Weak *Uncinia flaccida*
Johnson-rush *Juncus alexandri* subsp. *alexandri*
Leek-orchid, White/Mauve *Prasophyllum candidum/suttonii*
Mint-bush, Alpine *Prostanthera cuneata*
Nertera, Matted *Nertera granadensis*
Orites, Alpine *Orites lancifolia*
Phebalium, Alpine *Phebalium phylicifolium*
Plum Pine, Mountain *Podocarpus lawrencei*
Rusty-pods, Alpine *Hovea montana*
Sedge *Carex blakei*
Sky Lily *Herpolirion novae-zelandiae*
Speedwell, Snow *Derwentia nivea*
Tuft-rush, Fan *Oreobolus distichus*
Snow-grass, Horny *Poa fawcettiae*
Snow-grass, Soft *Poa hiemata*
Wallaby-grass, Alpine *Danthonia nudiflora*
Wattle, Alpine *Acacia alpina*

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Fig. 1. Wet sub-alpine heathland, Lake Mountain.

tions of terrestrial invertebrates.

The 47 bryophyte and 12 macrolichen species recorded by Cameron and Turner (1994) indicate the diversity of non-vascular flora at Lake Mountain (Table 2). Although none of the bryophytes recorded are known to be significant, the lichen *Cladonia staufferi* found in shrubby sub-alpine woodland is rare in sub-alpine habitats.

Doeg *et al* (1994) restricted their survey of fish and aquatic macroinvertebrates to sites on tributaries likely to be affected by the proposed new ski trails. They sampled fish by electrofishing and aquatic macroinvertebrates using the 'kick' sampling method once at each of four sites.

Significant Ecological Communities
Wet sub-alpine heathland

Wet sub-alpine heathland of the Echo Flat-Long Heath area is the most significant community at Lake Mountain in terms of its biogeographic and conservation values. These heathlands also represent the most fragile ecosystem due to their restricted distribution, sensitivity to disturbance and specific hydrological requirements. Their current vulnerability is heightened by the recognition that they are at present recovering from the impact of past cattle grazing activity, which ceased in 1964 (Ashton and Hargreaves 1983), fire disturbance, introduction of weeds, and the development of recreational facilities and their infrastructure.

The botanical significance of the wet heathlands of the study area can be demonstrated by an analysis of the most comprehensive listing of significant species for the region. Beauglehole (1983) lists 48 species which are recorded for the Lake Mountain Alpine Reserve and are considered on distributional criteria to have regional significance. Approximately 24 species (50%) can be considered to be exclusively or largely associated with wet sub-alpine heathland at Lake Mountain, demonstrating that the significance of this community for conservation of rare and threatened flora is disproportional to the very limited extent of the community within the landscape.

At Lake Mountain, wet sub-alpine heathland occupies the wettest sites, on peaty substrates, in broad, flat-bottomed depressions throughout the Echo Flat-Long Heath study area. The community occurs over an elevation range of 1350-1435 m asl and is

Table 2. Lake Mountain Bryophytes and Lichens.

Sub-Alpine Woodland (Grassy)	*Menegazzia ?platytrema*	*Balantiopsis diplophylla*
Bryophytes	*Parmelia* sp.	*Bryum* sp.
Catagonium politum	*Usnea molliuscula*	*Catagonium politum*
Grimmia trichophylla	*Usnea* sp.	*Chiloscyphus fissistipus*
Hypnum cupressiforme		*Dicranoloma menziesii*
Leptostomum inclinans	**Ecotonal Sub-Alpine Woodland**	*Dicranoloma robustum*
Leptotheca gaudichaudii	**with riparian elements**	*Grimmia trichophylla*
Lophocolea bidentata	**Bryophytes**	*Hypnum cupressiforme*
Lophocolea bispinosa	*Achrophyllum dentatum*	*Kurzia compacta*
Lophocolea muricata	*Acrobolbus concinnus*	*Lepidozia laevifolia*
Lophocolea semiteres	*Balantiopsis diplophylla*	*Leptostomum inclinans*
Orthodontium lineare	*Balantiopsis tumida*	*Leptotheca gaudichaudii*
Rhacomitrium crispulum	*Brachythecium paradoxum*	*Lophocolea biciliata*
Rhynchostegium tenuifolium	*Bryum billardieri*	*Lophocolea bidentata*
Sematophyllum amoenum	*Camptochaete arbuscula*	*Lophocoloea semiteres*
Lichens	*Catagonium politum*	*Metzgeria decipiens*
Cladonia sp.	*Dicranoloma menziesii*	*Orthodontium lineare*
Hypogymnia enteromorphoides	*Dicranoloma robustum*	*Ptychomnium aciculare*
Hypogymnia lugibris	*Grimmia trichophylla*	*Rhacomitrium crispulum*
Parmelia sp.	*Hypnodendron vitien:e*	*Riccardia crassa*
	Hypnum cupressiforme	*Sematophyllum amoenum*
	Jungermannia orbiculata	*Thuidium* sp.
Sub-Alpine Woodland	*Lophocolea bidentata*	*Wijkia extenuata*
(Shrubby)	*Lophocolea planiuscula*	*Zoopsis leitgebiana*
Bryophytes	*Lophocolea semiteres*	**Lichens**
Brachythecium paradoxum	*Plagiothecium denticulatum*	*Cladonia* sp.
Dicranoloma billardieri	*Polytrichum commune*	*Usnea* sp.
Dicranoloma dicarpum	*Rhacomitrium crispulum*	
Grimmia apocarpa	*Rhizogonium mnoides*	**Wet Sub-Alpine Heathland**
Hypnum cupressiforme	*Riccardia crassa*	**Bryophytes**
Lophocolea bidentata	*Sematophyllum amoenum*	*Balantiopsis diplophylla*
Lophocolea semiteres	*Sphagnum cristatum*	*Breutelia pendula*
Pohlia nutans	*Tayloria octoblephorus*	*Catagonium politum*
Rhacomitrium crispulum	*Thuidium sparsum*	*Grimmia trichophylla*
Rhynchostegium tenuifolium	*Wijkia extenuata*	*Hypnum cupressiforme*
Sematophyllum amoenum	**Lichens**	*Lophocolea bidentata*
Lichens	*Cladonia scabriuscula*	*Polytrichum commune*
Cladonia pyxidata		*Rhacomitrium crispulum*
Cladonia ramulosa	**Montane Riparian Thicket with**	*Rhychostegium tenuifolium*
Cladonia scabriuscula	**Cool Temperate Rainforest**	*Sphagnum cristatum*
Cladonia staufferi (rare)	**elements**	*Wijkia extenuata*
Cladonia subradiata	**Bryophytes**	
Hypogymnia enteromorphoides	*Achrophyllum dentatum*	

generally surrounded by extensive stands of sub-alpine woodland. In the Echo Flat area, wet heathland stands often merge with fringing stands of dry sub-alpine shrubland on the better-drained and more exposed sites. They may also merge with small fringing stands of montane riparian thicket on their more sheltered western margins.

Wet sub-alpine heathland is widely recognised as having a distinctive suite of rare and threatened plant species, many of which are restricted to this community. 11 of the 24 vascular species recorded within one quadrat along the Long Heath Trail are recognised by Beauglehole (1983) as regionally significant, of which the rarest

in the region are *Astelia alpina, Erigeron pappocromus, Nertera granadensis, Oreobolus distichus, Oreobolus oxycarpus* and *Podocarpus lawrencei.* Cryptogams, especially mosses, contribute significantly to both biomass and biodiversity, being represented in one quadrat by twelve species which account for one third of the recorded plant biodiversity. The most striking non-vascular species is the large cushion-forming moss *Breutelia pendula* which, like *Sphagnum cristatum,* forms extensive monospecific stands. These species perform a crucial role in the maintenance of water quality and stream flow and are dependent, in turn, on the hydrological stability of the surrounding head-

water catchments.

Wet sub-alpine heathlands support the greatest density of small mammals in the area (Table 3) (Jelinek and Belcher, 1994). Dusky Antechinus *Antechinus swainsonii*, was only recorded from wet sub-alpine heathland and its ecotones with montane riparian thicket and sub-alpine woodland. The Bush Rat *Rattus fuscipes* was abundant in all habitats, especially the wet sub-

alpine heathland and its ecotones (Fig. 2).

The Broad-toothed Rat *Mastacomys fuscus* has previously been recorded in wet sub-alpine heathland in the Echo Flat area (Atlas of Victorian Wildlife 1994). It may be present in other wet sub-alpine heathlands, although in low numbers. During this study *M. fuscus* was not recorded in three wet sub-alpine heathlands in the Long Heath area despite intensive trapping

Table 3. Lake Mountain wet sub-alpine heathland fauna.
Key: # = Sub-alpine woodland includes dry rock sub-alpine shrubland and grassy sub-alpine shrubland; @ = Common and Waterhouse 1972; * = introduced species.

Mammals	Ecological Vegetation Type
Antechinus, Brown *Antechinus stuartii*	Dry rocky sub-alpine grassland fringe with dense shrubs and rock outcrops
Antechinus, Dusky *Antechinus swainsonii*	Wet sub-alpine heathland and its ecotones with montane riparian thicket and sub-alpine woodland
Bat, White-Striped Freetail*Tadarida australis*	Wet sub-alpine heathland and sub-alpine woodland
*Deer, Sambar *Cervus unicolor*	Montane riparian thicket and sub-alpine woodland
*Dog/Dingo *Canis familiaris*	Wet sub-alpine heathland and sub-alpine woodland
*Fox *Vulpes vulpes*	Wet sub-alpine heathland and sub-alpine woodland
Possum, Leadbeaters *Gymnobelideus leadbeateri*	Sub-alpine woodland montane damp forest
Possum, Common Ringtail *Pseudocheirus peregrinus*	Sub-alpine woodland and montane damp forest
Rat, Bush *Rattus fuscipes*	Wet sub-alpine heathland and its ecotone with montane riparian thicket, sub-alpine woodland, dry rocky sub-alpine grassland fringe with dense shrubs and rock outcrops, grassy sub-alpine shrubland
Wombat, Common *Vombatus ursinus*	Wet sub-alpine heathland and sub-alpine woodland
Birds	
Cockatoo, Gang Gang *Callocephalon fimbriatum*	Sub-alpine woodland
Cuckoo, Fantailed *Cacomantis flabelliformis*	Sub-alpine woodland and montane riparian thicket
Currawong, Grey *Strepera versicolor*	Wet sub-alpine heathland and sub-alpine woodland
Currawong, Pied *Strepera graculina*	Sub-alpine woodland
Fantail, Grey *Rhipidura fuliginosa*	Sub-alpine woodland
Honeyeater, Crescent *Phylidonyris pyrrhoptera*	Sub-alpine woodland
Honeyeater, White-eared *Lichenostomus leucotis*	Wet sub-alpine heathland and sub-alpine woodland
Honeyeater, White-naped *Melithreptus lunatus*	Sub-alpine woodland
Kookaburra, Laughing *Dacelo novaeguineae*	Sub-alpine woodland
Lyrebird, Suberb *Menura novaehollandiae*	Sub-alpine woodland/montane riparian thicket ecotone
Nightjar, White-throated *Eurostopodus mystacalis*	Sub-alpine woodland
Owl, Boobook *Ninox novaeseelandiae*	Sub-alpine woodland
Pardalote, Striated *Pardalotus striatus*	Sub-alpine woodland
Pilotbird *Pycnoptilus floccosus*	Montane riparian thicket
Raven, Little *Corvus mellori*	Wet sub-alpine heathland and sub-alpine woodland
Robin, Flame *Petroica phoenicea*	Sub-alpine woodland
Robin, Eastern Yellow *Eopsaltria australis*	Sub-alpine woodland /montane riparian thicket ecotone
Rosella, Crimson *Platycercus elegans*	Sub-alpine woodland
Scrubwren, White-browed *Sericornis frontalis*	Wet sub-alpine heathland, montane riparian thicket and sub--alpine woodland
Silvereye *Zosterops lateralis*	Sub-alpine woodland
Shrike-thrush, Grey *Colluricincla harmonica*	Sub-alpine woodland
Swallow, Welcome *Hirundo neoxena*	Wet sub-alpine heathland and sub-alpine woodland
Thrush, Russet-tailed *Zoothera heinei*	Montane riparian thicket
Whipbird, Eastern *Psophodes olivaceus*	Montane riparian thicket
Whistler, Olive *Pachycephala olivacea*	Wet sub-alpine heathland montane riparian thickets
Whistler, Golden *Pachycephala pectoralis*	Sub-alpine woodland
Wattlebird, Red *Anthocharea carunculata*	Sub-alpine woodland
Reptiles and Amphibians	
Froglet, Common *Crinia signifera*	Wet sub-alpine heathland
Skink, Grass *Pseudemoia entrecasteauxii*	Sub-alpine woodland#
Skink , Southern Water *Eulamprus tympanum* CTF	Wet sub-alpine heathland and sub-alpine woodland#
Toadlet, Southern *Pseudophryne semimarmorata*	Wet sub-alpine heathland
Tree Frog, Alpine *Litoria verreauxii alpina*	Wet sub-alpine heathland

Table 3 cont.

Butterflies	Ecological Vegetation Type	Larval Food Plants@
Admiral, Australian *Vanessa itea* (Fabricius),1775	Wet Sub-alpine Heathland	Asteraceae
Brown, Common *Heteronympha merope merope* (Fabricius),1775	Wet Sub-alpine Heathland	Native grasses eg. *Poa* spp.
Painted Lady,Australian *Vanessa kershawi* (McCoy),1868	Wet Sub-alpine Heathland	Asteraceae
Swallowtail, Macleay's *Graphium macleayanum macleayanum* (Leach),1814	Wet Sub-alpine Heathland	*Tasmannia lanceolata* *Tasmannia xerophila* *Atherosperma moschatum*
White, Caper *Anaphaeis java teutonia* (Fabricius),1775	Wet Sub-alpine Heathland Sub-alpine Woodland	various species
White*, Cabbage *Pieris rapae rapae* (Linnaeus),1758	Wet Sub-alpine Heathland	mainly introduced species
Several unidentified species	All vegetation types	
Moth Species *Euphyia* sp.	Wet Sub-alpine Heathland	
Several other species of moths belonging to the Family Geometroidea	All vegetation types	

and searching for scats within suitable habitat (Table 4).

The Southern Water Skink *Eulamprus tympanum* (CTF), Alpine Tree Frog *Litoria verreauxii alpina*, Common Froglet *Crinia signifera* and Southern Toadlet *Pseudophryne semimarmorata* were recorded in wet sub-alpine heathland. Birds observed or heard included the Welcome Swallow *Hirundo neoxena*, Olive Whistler *Pachycephala olivacea*, White-browed Scrubwren *Sericornis frontalis*, White-eared Honeyeater *Lichenostomus leucotis*, Grey Currawong *Strepera versicolor* and Little Raven *Corvus mellori*.

Butterflies and moths (Table 3) observed in the wet sub-alpine heathland included Macleay's Swallowtail *Graphium macleaanum macleayanum* (Leach) (Fig. 3) and Australian Admiral *Vanessa itea* (Fabricius). Adult butterflies and moths were attracted to flowering plants, especially *Epacris paludosa*. Their larvae feed on a variety of plants in associated vegetation types, including the montane riparian thickets, cool temperate rainforest and sub-alpine woodland (Common and Waterhouse 1972).

Doeg *et al.* (1994) recorded 45 distinct macroinvertebrate taxa from small streams surrounded by wet sub-alpine heathland (Table 5). The substrate of these streams is characterised by boulders and cobbles with an average depth of about 10 cm and width of about 0.5-1 m,and they are partly shaded by dense streamside shrubs. The endangered Barred Galaxias *Galaxia fuscus* is known to occur in the Upper Taggerty catchment although only trout were recorded at one of the sampling sites during this survey.

The most diverse Order of aquatic macroinvertebrates was the Diptera (two-winged flies) represented by 12 taxa from five families. Most of the taxa were from the family Chironomidae. The Plecoptera (stoneflies) were represented by ten taxa, including representatives from all known Australian families: Eustheniidae, Gripopterygidae, Notonemouridae and Austroperlidae. Trichoptera were represented by eight taxa spread through six families. The Coleoptera (beetles) were represented by seven distinct taxa, all from the family Elmidae. The Ephemeroptera (mayflies) were represented by two taxa. The non-insect fauna comprised six taxa, the most common being the Amphipoda. Other common taxa were immature Plecoptera and Oligochaeta.

Montane riparian thicket, and cool temperate rainforest

These two communities are represented by a structural and floristic continuum from mature cool temperate rainforest, through stands which are undergoing secondary succession at the ecological and altitudinal limit of the community, to mon-

Table 4. Predator scat analyses.
N.B. Scats were identified by smell and by diameter. A small proportion of scats may be misidentified.

Scats	Prey
6 x fox	Bush Rat
1 x fox	Brown Antechinus
5 x fox	Dusky Antechinus
1 x fox	Antechinus sp.
2 x fox	Ringtail Possum
1 x fox	Bird
2 x fox	Bush Rat, Dusky Antechinus
1 x fox	Ringtail Possum, Bush Rat, Beetle
1 x fox	Ringtail Possum, Dusky Antechinus
1 x fox	Wombat, Dusky Antechinus
1 x fox	Wombat, Bush Rat
1 x fox	Invertebrates-beetles, crustacea
1 x dog/dingo	Invertebrates-beetles,yabbies
1 x dog/dingo	Bush Rat, Ringtail, Antechinus sp.
1 x dog/dingo	Wombat, Ringtail, Bush Rat, Antechinus sp.
1 x dog/dingo	Dusky Antechinus

Fig. 2. Fauna survey site, wet sub-alpine heathland, Lake Mountain.
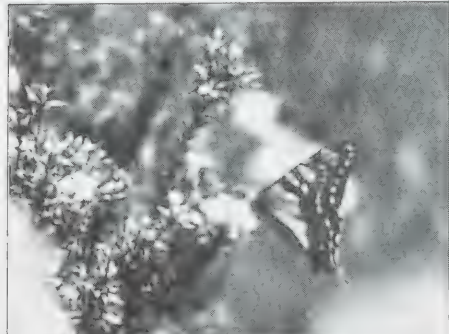
Fig. 3. Macleay's Swallowtail *Graphium macleayanum macleayanum* on *Epacris paludosa*, Lake Mountain.

Table 5. Acquatic Macroinvertebrates recorded by Doeg, T., Saddlier, S. and Reed, J. (1994). N.B. 1. 'spp.' means individuals could not be or were not identified to lower taxonomic designations. 2 'sp.1' and 'sp.2' refer to numbers in the voucher collection held in the Museum of Victoria.

A. INSECTA
Ephemeroptera
Baetidae
 Baetis spp.
Leptophlebiidae
 Austrophlebioides
 spp.

Plecoptera
Austroperlidae
 Austroheptura
 neboissi
Eustheniidae
 Eusthenia venosa
Gripopterygidae
 Dinotoperla bre-
 vipennis
 Dinotoperla hirsuta
 Eunotoperla ker
 shawi
 Leptoperla neboissi
 Leptoperla spp.
 Riekoperla rugosa
 group
Notonemouridae
 Austrocercella till-
 yardi
 Notonemoura
 lynchi

Trichoptera
Calocidae
 Calocidae spp.
Conoesucidae
 Conoesucidae spp.
Ecnomidae
 Ecnomus deani
Hydrobiosidae
 Taschorema evansi
 Taschorema kim-
 minsi
Hydropsychidae
 Austropsyche victor
 iana

Cheumatopsyche
 sp. 2
Tasimiidae
 Tasiagma ciliata

Coleoptera
Elmidae
 Austrolimnius spp.
 Austrolimnius
 metasternalis
 Austrolimnius
 waterhousei
 Kingolus spp.
 Notriolus victoriae
 Simsonia spp.

Diptera
Chironomidae
 Rheotanytarsus spp.
 Riethia spp.
 Paratanytarsus spp.
 Tanytarsus spp.
 Thienemaniella spp.
 Cricotopus spp.
 Procladius spp.
 Pentaneura spp.
Empididae
 Empididae sp.2
Psychodidae
 Psychodidae spp.
Simuliidae
 Austrosimulium
 cornutum
Tipulidae
 Tipulidae sp.1

B. NON-INSECTA
 Oligochaeta spp.
 Hydracarina spp.
 Gastropoda spp.
 Psidium spp.
 Amphipoda spp.
 Ostracoda spp.

tane riparian thicket. All stands along this continuum are significant because of their extreme fire-sensitivity, habitat-specificity, hydrological sensitivity, their linear configuration which renders them particularly susceptible to edge effects, their restricted occurrence within the landscape, and their concentration of rare and threatened, fire-sensitive and moisture-dependent plant species. Cool temperate rainforest and, to a lesser extent, montane riparian thickets, are considered to have special evolutionary

and biogeographic significance based on their relict and refugial status and also, their Gondwanic evolutionary origins.

Stands undergoing secondary succession have the potential to regenerate as mature cool temperate rainforest although the time required for full recovery may be considerable. The Interim Reference Areas Advisory Committee (1977) suggests that Nothofagus-Leptospermum cool temperate montane rainforest scrub may require two hundred years to recover to full floristic potential following a major crown fire. Despite their small size, such secondary stands have ecological significance in a local context as they potentially represent the highest occurrences of cool temperate rainforest in the Lake Mountain area at 1400 m asl.

Three high altitude occurrences of rainforest vegetation occur in the Echo Flat-Long Heath area. The largest occurs at an elevation of 1370-1395 m in a gully-head west of Royston Gap Road, 500 m south of Triangle Junction. It is a secondary stand, structurally transitional between montane riparian thicket and cool temperate rainforest. Another occurs at an elevation of 1410 m and is centred on a single mature Nothofagus individual associated with a minor drainage line entering Echo Flat downslope of the Muster Trail, 200 m southeast of Triangle Junction. Although a minor occurrence of cool temperate rainforest, this site is significant for the maturity of *Podocarpus lawrencei* associated with a mature Nothofagus individual, and the association of *Wittsteinia vacciniacea* and *Trochocarpa clarkei* in the ground layer.

An important gully-head occurrence of montane riparian thicket vegetation occurs in the Long Heath area. Whilst the stand currently has the structural and floristic characteristics of montane riparian thicket, there is evidence that it represented mature cool temperate rainforest prior to the destruction of its *Nothofagus cunninghamii* closed canopy in the 1939 wildfire, and that the regenerating stand is currently undergoing secondary succession. Evidence of secondary succession includes the following observations:

1. the stand is currently co-dominated by *Leptospermum grandifolium* (estimated cover 45%) and *Nothofagus cun-*

ninghamii (estimated cover 35%), most of which are multistemmed, having resprouted from the base of fire-killed parent crowns;

2. at least one fire-killed stag is emergent above the 2-4 m high closed-scrub in the boggy centre of the stand;

3. charcoal scars are evident on the butts of Nothofagus stumps, some of which were completely fire-killed, others are encircled by a ring of coppice stems now 5-8 m tall;

4. single-stemmed emergent pole-stage *Eucalyptus pauciflora* and *Pultenaea muelleri* and *Prostanthera cuneata* within the closed-canopy Leptospermum-Nothofagus stand suggest these scattered sclerophyll taxa invaded the former Nothofagus stand immediately following its incineration in 1939.

Cool temperate rainforest is the most fire-sensitive community in the region. Stands in the Echo Flat-Long Heath area support good populations of a number of species of state or regional significance including *Wittsteinia vacciniacea, Trochocarpa clarkei* and *Podocarpus lawrencei*. The cryptogamic flora is well represented with at least 25 species recorded within one quadrat, accounting for at least 40% of the plant biodiversity recorded within a 900 m² plot.

Such ecologically significant occurrences of cool temperate rainforest at their altitudinal limit need protection from disturbance which might increase the risk of recurrent wildfire, dessication, windthrow, sedimentation, deleterious alteration to the drainage characteristics of the site and invasion by exotic species such as Blackberry (**Rubus fruticosus* spp. agg.) which is recorded in the area.

Uncommon bird species or those associated with restricted habitats such as the Olive Whistler *Pachycephala olivacea*, and Pilotbird *Pycnoptilus floccosus*, were recorded only in montane riparian thickets and their ecotones. The Fantailed Cuckoo *Cacomantis flabelliformis*, Superb Lyrebird *Menura novaehollandiae*, Russet-tailed Thrush *Zoothera heinei*, Eastern Yellow Robin *Eopsaltria australis*, Eastern Whipbird *Psophodes olivaceus* and White-browed Scrubwren were also recorded.

Sub-alpine woodland

As a vegetation type, sub-alpine wood-

land is not considered to have specially high conservation significance. However, the community is represented by a number of distinct variants and forms which have diversified in response to variations in site exposure, depth of soil, soil moisture and fire history.

An ecologically significant stand of sub-alpine woodland occupying a gently south-east-trending basin is located south-east of the major rocky ridgeline due west of Long Heath. The stand is dominated by Eucalyptus pauciflora and is significant for the uniformly high (up to 50%) cover of *Wittsteinia vacciniacea* over an extensive area in the absence of woody species normally indicative of montane riparian thicket or cool temperate rainforest affinity. The only associated species indicating such riparian affinity are the fern *Blechnum pennamarina,* which is scattered in the stand, and the sedge *Carex appressa,* which is rare in the stand. This large and excellent stand of *Wittsteinia* is associated with a mixed shrub layer of *Tasmannia xerophila* (which is locally dominant), *Prostanthera cuneata* and *Pultenaea muelleri.* This significant stand of vegetation is dependent on the particular drainage characteristics of the site and is likely to be highly sensitive to any changes to site hydrology.

Another significant form of sub-alpine woodland is described in Part 1 under characteristics of Leadbeater's Possum habitat in subalpine woodland (*The Victorian Naturalist* **112**, 1995, 112-15).

More typical shrubby understoreys are dominated by a suite of sclerophyllous shrubs of which the most prominent are *Acacia alpina, Oxylobium alpestre, Ozothamnus secundiflorus, Prostanthera cuneata, Pultenaea muelleri* and *Tasmannia xerophila.* In stands which are ecotonal with dry sub-alpine shrubland, *Olearia algida, Oxothamnus hookeri* and *Phebalium phylicifolium* are prominent

Grassy and herbaceous understoreys in the sub-alpine woodland are best developed on sheltered western and northwest aspects. They are dominated by *Poa ensiformis,* sometimes almost to the exclusion of any other species, together with a suite of forbs and other graminoides of which the most prominent are *Asperula gunnii, Asperula pusilla, Caladenia lyalii, Carex*

breviculmis, Hydrocotyle hirta, Leptostigma reptans, Lycopodium fastigiatum and *Viola hederacea* subsp. *hederacea.*

A diversity of bryophytes and macrolichens occur throughout the sub-alpine woodland. The lichen Cladonia staufferi was recorded in two quadrats in shrubby sub-alpine woodland. This lichen is rare in sub-alpine habitats.

The White-striped Freetail Bat *Tadarida australis,* Common Ringtail Possum *Pseudocheirus peregrinus,* Brown Antechinus *Antechinus stuartii,* Bush Rat *Rattus fuscipes,* Grass Skink *Pseudemoia entrecasteauxii* and numerous bird species, including the Boobook Owl *Ninox novaeseelandiae* and White-eared Honeyeater *Lichenostomus leucotis* were common throughout the various forms of sub-alpine woodland. The White-throated Nightjar *Eurostopodus mystacalis,* a summer migrant to the area, was also recorded.

Significant Fauna

The discovery of Leadbeater's Possum, *Gymnobelideus leadbeateri* McCoy in sub-alpine woodland within the study area is significant and is reported in Part 1 (*The Victorian Naturalist* **112**, 1995, 112-15).

Although not recorded during this survey, according to the Land Conservation Council (1991), the following significant species are likely to occur in the area. More extensive and intensive surveys are required to determine their occurrence and distribution in the Lake Mountain area.

- **The Broad-toothed Rat** *Mastocomys fuscus* is rare in Victoria (CNR 1995) and although not recorded during this study, it has previously been recorded in the area (Atlas of Victorian Widlife 1994). Analysis of predator scats collected from tracks in or near wet subalpine heathland reveals that wild dogs, dingoes and foxes prey on a variety of native fauna, including *Antechinus swainsonii* (Table 4). Green and Osborne (1981) highlight intensive and selective predation by foxes on M. fuscus in comparison with *R. fuscipes* which may be less palatable or more difficult to capture. This could account for *M. fuscus* not being recorded during this study. They also propose that each fox consumes 4-11 small mammals per

day, although the diet changes through the seasons, depending on the relative abundance of invertebrates and small mammals.

- **Smoky Mouse** *Pseudomys fumeus* is vulnerable in Victoria (CNR 1995) and occurs in sub-alpine woodland in surrounding areas (LCC 1991).

- **Pink Robin,** *Petroica rodinogaster*, is a significant species that lives and breeds in the upland cool temperate rainforests of the Central Highlands (LCC 1991).

The Alpine Tree Frog *Litoria verreauxii alpina* was recorded in wet sub-alpine heathland (Jelinek and Belcher 1994). This subspecies of *Litoria verreauxii* is restricted to sub-alpine communities (LCC 1991) and is currently classified as insufficiently known (suspected rare, vulnerable or endangered) (CNR 1995).

A diversity of aquatic macroinvertebrates from a range of invertebrate groups occurs in tributary streams of the Taggerty and Royston Rivers and Keppel Hut Creek (Doeg *et al.* 1994). Brown or Barred Galaxias *Galaxia fuscus* is listed as endangered on Schedule 1 of the Endangered Species Protection Act 1992 and as a threatened taxon on Schedule 2 of the Flora and Fauna Guarantee Act 1988. It is also classified as endangered by CNR (1995). *Galaxia fuscus* has been recorded in the Taggerty River, 1 km downstream of the study area (Doeg *et al.* 1994).

Significant Flora

A comprehensive census of the flora of the study area was compiled and compared with a statewide or regional overview of significant species. Gullan *et al.* (1990) provide the most consistent overview of rare or threatened plants of state or national significance. Beauglehole (1983) provides the only statewide review of plant species of regional significance. Both listings need to be reviewed for consistency and updated in the light of taxonomic revision and current ecological and distributional information.

A comparison of a composite census with Gullan *et al.* (1990) and Beauglehole (1983) indicates that the Department of Conservation and Natural Resources' Flora Information System (FIS) contains reliable quadrat or definable area records for the

study area of two species (*Brachyscome obovata* and *Wittsteinia vacciniacea*) considered rare in the state by Gullan *et al.* and a further 31 species considered regionally significant by Beauglehole. Three additional taxa, *Baeckea utilis* var. *latifolia*, *Oreobolus oxycarpus* subsp. *oxycarpus* and *Trochocarpa clarkei*, are considered rare in Victoria and two additional species are considered regionally significant. One of these, *Cardamine lilacina*, is a poorly-known polymorphic taxon which is considered by some authorities to represent a number of distinct species. The second, *Trisetum spicatum* subsp. *australiense*, was not recorded by Beauglehole or in previous FIS records within the Central Highlands region, and the Echo Flat record is therefore inferred to be of regional significance.

Although an additional species of state significance, *Coprosma moorei*, has not been confirmed by Flora Information System quadrat records for the study area, this rare sub-alpine species is reliably recorded for Lake Mountain by Beauglehole (1983) and is likely to occur in the Echo Flat area.

Distributions of these plants indicate that each of the five species of state or national significance, as well as *Coprosma moorei*, and 29 of the 33 species of regional significance, occurs at, or near, the western limit of its geographic range within the study area. The only exceptions to this pattern are two grasses, *Hierochloe redolens* and *Poa fawcettiae*, which have disjunct occurrences in sub-alpine vegetation in the Grampians, and the Alpine Bog Sedge *Carex blakei*, which has a disjunct lowland record for Gellibrand Hill. This observation clearly serves to illustrate the outstanding biogeographic significance of the Lake Mountain plateau as the western limit of the Australian alps in south-eastern Australia. Without exception, all 38 species are of regional or state significance because they are restricted to alpine or sub-alpine environments which are rare and at their geographic limit within the region or the state.

Three taxa are of special biogeographic and conservation significance because they are endemic within the Central Highlands region as well as rare or restricted within Victoria. Two of these, *Baeckea utilis* var. *latifolia* and *Trochocarpa clarkei*, were not

considered rare in the state by Gullan *et al.* (1990) but are here considered worthy of such status. The third Victorian endemic, *Wittsteinia vacciniacea*, deserves particular consideration as its full biogeographic and evolutionary significance has not been fully appreciated.

In his synopsis of the family Alseuosmiaceae in New Zealand, New Caledonia, Australia and New Guinea, the Dutch systematist van Steenis (1984) established the true Gondwanic affinities of *Wittsteinia vacciniacea*, placing it alongside a small number of species which occur in New Caledonia and Papua New Guinea, within an expanded circumscription of the genus *Wittsteinia.* The Victorian endemic taxon thus becomes the only member, in south-eastern Australia, of the newly circumscribed Gondwanic family Alseuosmiaceae. The family is otherwise represented only by the genus *Crispiloba,* with a single species in rainforest on the Bellenden-Ker Range in north Queensland, and the genus *Alseuosmia,* which consists of a complex of taxa in New Zealand.

Most earlier writers had failed to appreciate the distinctly Gondwanic origins of *Wittsteinia* and other members of this small family. Prior to 1984, most Australian botanists had considered the affinities of the Victorian endemic to lie with the Laurasian family Ericaceae or its southern sibling family Epacridaceae. Most overseas systematists had relegated the members of the Alseuosmiaceae to affinity with a bewildering variety of prodominantly Laurasian or pantropical families, including Caprifoliaceae, Escalloniaceae, Loganiaceae, Saxifragaceae, Rubiaceae, Pittosporaceae and Grossulariaceae.

Acknowledgements

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Spiders in Morwell National Park

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Abstract
This article lists the species of spiders found in Morwell National Park in eastern Victoria. The Park has varied terrain and vegetation. A survey of spiders was conducted over a year. Spiders were collected by direct seaching during the day and at night. Comments are made on the habitats of some of the species found. (*The Victorian Naturalist* **114**, 1997, 40-44).

Introduction

The Morwell National Park is located in the Strzelecki Ranges at around 38^0 22' S, 146 ^{0} 24' E and is 16 km south of Morwell. It covers an area of approximately 500 hectares and ranges in altitude from approximately 120-460 m above sea level (Fig. 1). The vegetation includes warm temperate rain forest, dry sclerophyll forest and cleared land once used for farming. The entire Park has been subject to varying degrees of human disturbance. The area was last selectively logged in 1956 and grazing continued in parts until 1986. The Park was proclaimed in 1967 and there have been several later extensions.

Previous fauna surveys within the Park concentrated upon the vertebrate fauna. The Department's fauna lists (March 1979, September1981 and November 1985) refer only to mammals, birds, reptiles and amphibians. The spider survey was probably the first which emphasized invertebrate fauna.

Methods

A survey of Spiders in Morwell National Park was initiated at the request of Ken Harris, a local naturalist and colleague. The then Department of Conservation and Natural Resources issued a Research Permit (934/083) for the spider survey. The Permit allowed me to search, collect and retain spiders found within the boundaries of Morwell National Park for the year commencing 1 July 1994. During the year I visited the Park on fourteen occasions (nine during the day and five at night) for the specific purpose of finding spiders. Three visits were made in July 1994, two in September 1994, one in November 1994, two in January 1995, five in February 1995 and one in March 1995. Spiders were collected from both sections of the Park - Fosters Gully and Billys Creek areas.

All spiders were collected by hand.

Spiders were most often found under eucalyptus or acacia bark. Others were found in webs, under fallen logs, in leaf litter, amongst grass or rocks on the edge of the creek. Several of what appeared to be funnel-web spider burrows were sighted, but attempts to collect spiders by excavation were unsuccessful. A few huntsmen and wolf spiders were found at night when their eyes reflected the torchlight. With the benefit of the experience, the use of pitfall traps, litter sampling and beating trays would have resulted in a larger quantity and probably more species of spiders being found.

The spiders were collected alive and placed at the site of collection in glass jars. On returning home the spiders were preserved in 75% alcohol and the vials labelled. Upon completion of the survey, the specimens were submitted to David Hirst, Arachnologist at the South Australian Museum, for identification.

Results

The spider survey species list is based upon David Hirst's identifications. David Hirst used literature available in the South Australian Museum and by comparison with previously identified material to identify the specimens collected. In providing the identifications, he commented, "Some identifications have been difficult as the spiders belong to families which have not been worked at all and have few described species" and then added that, 'a few juvenile spiders were too small to enable identification. Likewise, spiderlings which had recently emerged from their egg-sac were indeterminate (too young or damaged to identify to species level).

The following abbreviations are used.
? - tentative identification (particularly for immature specimens)
cf - not that species but very similar and possibly part of a species complex.
penult - penultimate instar
juv - juvenile

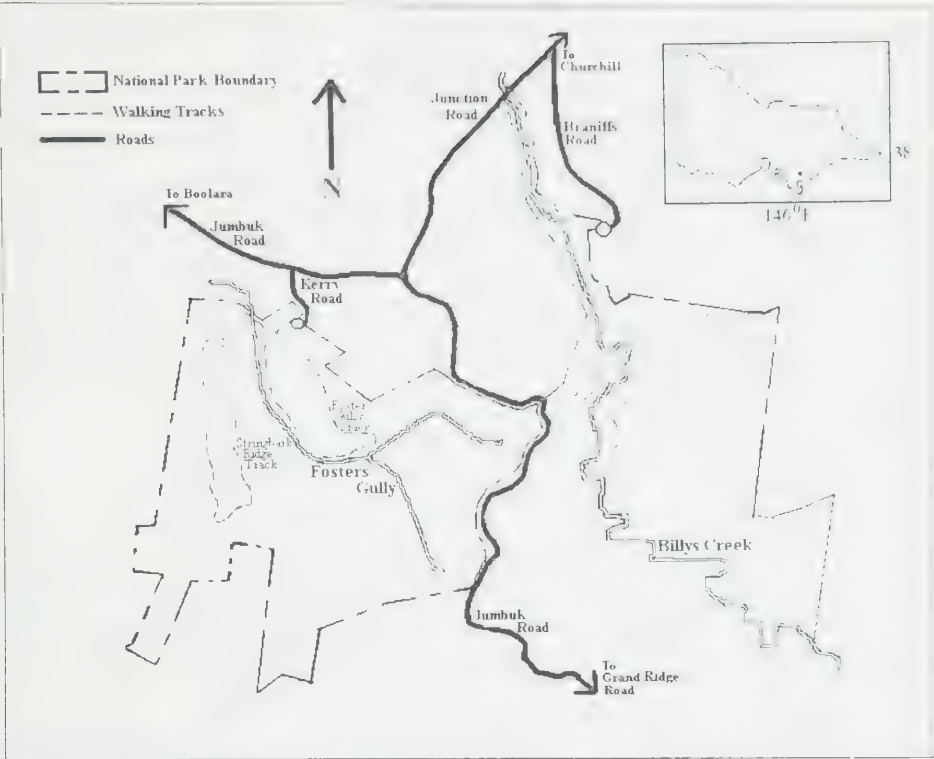[1] 23 Manuka Street, Churchill, Victoria 3842

Fig. 1. Morwell National Park, Victoria.

Spiders are in the arachnid order ARANEAE and consist of two main sub-orders, the MYGALOMORPHAE and ARANEOMORPHAE . The species are listed in their respective sub-orders and families. The scientific name of the spider is followed by the name of the arachnologist who first described the species and the date of publication. The sex of the specimens, date of collection and, where relevant, the stage of development is stated.

While searching for spiders numerous other invertebrates were discovered and several specimens were positively identified (de Souza-Daw 1995a, 1995b). Other arachnids included indigenous scorpions, pseudoscorpions, harvestmen and mites.

Remarks

The 281 spiders collected during this survey are now deposited in the South Australian Museum and the Museum of Victoria. Only four (or 1.5%) of the spiders collected were mygalomorphs. This relatively low proportion is probably due to the effect of human disturbance in the

The species listing of spiders reveals

	ARANEOMORPHAE	MYGALOMORPHAE	TOTAL
FAMILIES	21	2	23
SPECIES (including tentative identifications)	68	2	70

The spiders have been identified as

	ARANEOMORPHAE	MYGALOMORPHAE	TOTAL
MALE	69	-	69
FEMALE	135	2	137
JUVENILES (including indeterminate)	73	2	75
TOTAL	277	4	**281**

SPIDER SURVEY

FAMILY	SPECIES	COLLECTION DETAILS
	MYGALOMORPHAE (Primitive Spiders)	
HEXATHELIDAE (Funnel-web Spiders)	*Teranodes* ? *otwayensis* (Raven, 1985)	2 **juv** 7/9/94, ? **F** 20/11/94
NEMESIIDAE (Trap-door Spiders)	*Stanwellia grisea* (Hogg, 1901)	?**F** 9/10/94
	ARANEOMORPHAE (Modern Spiders)	
AMAUROBIIDAE (Lace-web Spiders)	genus ? sp. 1	**penult M** 7/9/94, **F** 20/11/94
	genus ? sp. 2	**F** 6/7/94, **juv** 21/7/94, **F** 7/9/94
	genus ? sp. 3	**F** 21/1/95
	Metaltellinae sp.	**F** 7/9/94
	Storenosoma sp.	**M** 20/11/94, **F** 21/11/94, **penult M** 25/2/95
ARANEIDAE (Orb Weaving Spiders)	*Arachnura higginsi* (Koch, 1872)	**F** 25/2/95
	Araneus eburnis (Keyserling, 1886)	**penult M** 6/7/94, **juv** 6/7/94, **penult M** 13/2/95, **penult F** 13/2/95, **juv** 22/2/95
	Araneus fuliginatus (Koch, 1872)	**F** 7/2/95
	Araneus cf *furcifera* (Keyserling, 1886)	**M** 22/2/95
	Araneus nigropunctatus (Koch, 1871)	**F** 18/1/95
	Araneus sp. 5	2 **juv** 7/2/95
	Araneus sp. 6	**penult F** 18/1/95, **penult M** 21/1/95
	Eriophora heroine (Koch, 1871)	**F** 13/2/95
	Eriophora pustulosa (Walckenaer, 1841)	**F** 7/2/95
	Nephila ? *edulis* (Labillardiere 1799)	**juv** 7/2/95
CLUBIONIDAE (Sac Spiders)	*Cheirocanthium* ? *gracile* Koch, 1873	**juv** 18/1/95
	Clubiona cf *cycladata* Simon, 1909	**M** 9/10/94, **F** 7/2/95, **penult. M** 22/2/95
	Clubiona sp.2	**F** 10/7/94
	Clubiona sp.3	**F** 21/7/94, 2 **F** 6/9/94, 2 **F** 7/9/94
	Corinnomma sp.	**M** 7/2/95
CTENIDAE (False Wolf Spiders)	? genus sp.	**penult F** 21/11/95
CYCLOCTENIDAE (Lace-web Spiders)	*Cycloctenus* sp.1	2 **F** 21/1/95
	Cycloctenus sp.2	**juv** 6/9/94, 2 **juv** 21/1/95
DESIDAE (Lace-web Spider)	*Badumna insignis* (Koch, 1872)	3 **F** 6/7/94, 2 **F** 10/7/94 **penult F** 7/9/94
	Badumna longinquus (Koch ,1867)	2 **penult M** 6/7/94 2 **juv** 10/7/94, **juv** 6/9/94 **F** 7/9/94, **penult M** 7/9/94 **F** 13/2/95
	Badumna sp.3	5 **F** 22/2/95
	Badumna sp. indeterminate	**juv** 18/1/95, **juv** 6/9/95 **juv** 22/2/95, 2 **juv** 21/1/95
	Paramatachia sp.	2 **juv** 21/1/95
	genus? sp.	**F** 6/7/94
GNAPHOSIDAE (Ground Spiders)	?genus sp.1	**M** 7/9/94, **F** 20/11/94
	?genus sp.2	**F** 10/7/94, **penult F** 13/2/95
	?genus sp.3	**penult F** 6/7/94 **penult M** 6/7/94
	?genus sp.4	**F** 7/2/9
	Hemicloea sp.	**penult M** 13/2/95
HETEROPODIDAE (Huntsman Spiders)	*Delena cancerides* (Walckenaer, 1805)	**juv** 6/9/94, **juv** 18/1/95 **juv** 21/1/95, **F** 7/2/95 3 **M** 13/2/95, **F** 13/2/95

			2 M 22/2/95
	Eodelena melanochelis (Strand, 1913)		M 21/7/94, F 21/7/94
			M 6/9/95
	Isopeda montana Hogg, 1902		juv 10/7/94, F 6/9/94
			juv 21/1/95, F 7/2/95
			F 13/2/95, juv 22/2/95
	Olios praecinctus (Koch, 1865)		M 6/9/94, juv 21/1/95
			penult M 7/2/95
LAMPONIDAE	*Lampona cylindrata* (Koch, 1866)		F 6/7/94, juv 6/7/94
(White-tailed Spiders)			F 10/7/94
LINYPHIIDAE	*Laperousea* cf. *cupidinea* (Simon, 1908)		F 7/9/94
(Sheet-web Spiders)			
LYCOSIDAE	*Lycosa furcillata* Koch, 1867		juv 22/2/95
(Wolf Spiders)	*Lycosa* sp.2		2 juv 22/2/95
	Trochosa sp.		2 M 19/2/95, 8 19/2/95
			penult F 19/2/95
			spiderling 19/2/95
			and four eggsacs,
			2 M 22/2/95
			penult M 22/2/95
			9 M 22/2/95 and eggsacs
	Venator fuscus Hogg, 1900		F 19/1/95
MIMETIDAE	*Australomimetus?maculosus* (Rainbow, 1904)		penult F 18/1/95
(Pirate Spiders)	*Australomimetus* sp.2		F 18/1/95
NICODAMIDAE	*Ambicodamus southwelli* Harvey, 1995		4 F 6/7/94, 3 juv 6/7/94,
(Red and Black Spiders)			4 F 10/7/94, 2 F 6/9/94
	Novodamus nodatus Harvey, 1995	3	F 21/7/94, penult F 7/2/95
PISAURIDAE	*Dolomedes* sp.		2 juv 19/2/95,
(Fishing Spiders)			penult F 22/2/95
SALTICIDAE	*Breda jovialis* (Koch, 1879)		F 6/7/94
(Jumping Spiders)	*Helpis minitabunda* (Koch, 1880)		F 10/7/94, juv 10/7/94
			juv 21/7/94, F 6/9/94
	Hypoblemum sp.		F 22/2/95
	Paraplatoides nigrum Zabka, 1992		M 21/7/94, F 21/7/94
SEGESTRIIDAE	*Ariadna* ? *major* Hickman, 1929		juv 6/7/94, 2 F 10/7/94
(Six-eyed Spiders)	*Segestria* ? *raleighi* (Hogg, 1900)	3	juv 6/7/94, F 10/7/94
			juv 10/7/94, F 21/2/94
			F 7/9/94
STIPHIDIIDAE	*Stiphidion facetum* Simon, 1902		4 penult
			M 6/7/94, F 10/7/94
			9 penult 10/7/94, F 21/7/94
			penult F 21/7/94
			6 penult M 21/7/94
			2 M 6/9/94, penult F 6/9/94
			M 7/9/94, penult M 7/9/94
			penult F 7/9/94, 2 juv 7/9/94
			M 20/11/94, 2 F 20/11/94
			F 21/1/95, juv 7/2/95
TETRAGNATHIDAE	*Deliochus zelivira* (Keyserling, 1887)		2 M 7/2/95, 3 juv 7/2/95
	? *Nanometa* sp.		M 18/1/95, F 19/3/95
	Phonognatha graeffei (Keyserling, 1865)		juv 18/1/95
	Tetragnatha valida Keyserling, 1887		juv 21/7/94, F 7/2/95
			M 14/2/95, 3 F 14/2/95
			2 F 19/2/95, 3 M 22/2/95
			3 F 22/2/95, 2 juv 22/2/95
THERIDIIDAE	*Achaearanea* sp.		F 13/2/95
(Cob-web Spiders)	*Moneta* sp.		penult 21/7/94
	Theridion ? *extrilidium* Keyserling, 1890		2 F 18/1/95, 2 F 21/1/95
			F 25/2/95, F 19/3/95
THOMISIDAE	*Sidymella* sp.1		penult F 6/7/94, M 21/1/95
(Flower Spiders)	*Sidymella* sp.2		juv 21/1/95

	Stephanopis cambridgei Thorell, 1870	F 6/7/94. M 6/7/94
		juv 6/7/94.penult F 7/2/95
	Stephanopis sp.2	F 6/7/94, penult F 6/7/94
ULOBORIDAE	Philoponella congregabilis (Rainbow, 1916)	6 F 21/1/95. F 25/2/95
		16 spiderlings 25/2/95
		2 penult F 19/3/95
Indeterminate		spiderling 22/2/95

Park, the reliance upon direct searching in this survey and, because these spiders are mainly burrowing spiders, they are more difficult to find. The four mygalomorphs were found under weathered logs. The sex of the spiders was identified in the 206 adult and penultimate specimens. The relative high proportion of females 137 (or 66.5%) is probably because generally female spiders are larger and longer lived, hence more likely to be found by direct searching. Juveniles totalled 75 (or 26.5%). This figure reflects the dates when most visits were made to the Park to collect specimens.

The survey resulted in 70 species being found from 23 families. These figures include tentative identifications and specimens which have been recognized as being from undescribed species. Had pitfall trapping and litter sampling techniques been utilized, the number of ground dwelling species found would probably have been much greater. The varied habitats within the Park probably results in a diverse number of spiders (and other arthropods). All spiders collected are believed to be indigenous to Australia.

The Amaurobiids and Desids in the Park prefer the hollows and deep grooves in mature stringybarks. The Small Black House Spider *Badumna longinquus* as well as inhabiting the stringybarks, also takes a liking to the treated-pine structures in the Park for constructing their webs. Another spider which has adapted well to the human structures is the Hump Spider *Philoponella congregabilis* which was commonly sighted under the permanent wooden picnic tables and seating. The araneids frequently construct their orb webs between the wires in the Park's fencing.

Most clubionids, gnaphosids, heteropodids, lamponids and nicodamids were found under the bark of mature Manna Gums *Eucalyptus viminalis*, Mountain Grey Gums *Eucalyptus cypellocarpa* and Blue Gums *Eucalyptus globulus*). Many spent refuges and egg-sacs were found under the bark of eucalypts and often more than one species was found under the bark of the same tree.

The Crinoline Spider *Stiphidion facetum* was the spider most commonly found under logs.They appear to prefer the underside of logs which have been burnt by fire. Lycosids were also found under logs and amongst leaf litter and those in the genus *Trochosa* preferred more moist conditions. The pisaurids and tetragnathids were found along the creek banks.

The diversity of Araneae in the Park indicates that there is also a diverse range of insects. Spiders are dependent upon insects, while birds, other spiders and predatory wasps are presumably the main predators of the Park's spider population.

The survey of Spiders in Morwell National Park adds substantially to our knowledge of the Park's invertebrate fauna. Hopefully the listing of species found in this survey will be of interest and benefit to those with an interest in arachnology. In time, others may add to the species list for Spiders in Morwell National Park.

Acknowledgements

References

de Souza-Daw, R. (1995 a). Fauna (Other than spiders) in Morwell National Park *Latrobe Valley Naturalist* **379,** 4-6.
de Souza-Daw, R (1995 b). Invertebrates (Other than spiders) in Morwell National Park. *Friends Morwell National Park Newsletter* **November 1995,** 2-4.

From our Naturalist in Residence, Glen Jameson

Middle Yarra Timelines
True Spring

The weather begins to stabilise with longer sequences of warm days interspersed by sometimes tempestuous stormy changes featuring high rainfall. Warmth and rain combine to imbue everything with an intoxicating and rejuvenating life force. Many young birds and mammals begin the weaning process and leave nests, dreys and hollows to explore the world and migratory birds arrive to glean the wealth of productivity. The flowering process moves from the hilltops and valleys to focus on riverbanks and wetlands.

The droning morning chant of the Common Bronzewing Pigeon resonates on the tree trunks along the **Riparian forest**. Rhythmic and deeply intoned, it is a morning mantra for the early risers - Om, Om, Om, booming out across the River valley. Flowering Manna Gums feed Red Wattlebirds and Eastern Rosellas, the latter involved heavily in the courting, breeding, feeding and weaning process, a common activity for wildlife during True Spring. The newly arrived migrants - Sacred Kingfisher, Rufous Whistler and Satin Flycatcher - busy themselves along the Yarra corridor, while Dusky Woodswallows are already nesting.

Deep under the Riverbanks in a breeding chamber of its burrow, a Platypus lays eggs that will soon hatch. Juveniles of the Common Galaxia, Spotted Galaxia, Tupong, and Australian Grayling are migrating upstream from the sea, passing Silver Eels and mature Short-finned Eels migrating downstream to estuaries.

Towards the end of True Spring , the river valley becomes the focus of flowering with the white flowers of Burgan, Christmas Bush, Snowy Daisy-bush, Swamp Paperbark and Tree Everlasting dominating the riverscape. Many other plants colour the riverine scene including River Bottlebrush, Prickly Moses, Hemp Bush, Large Kangaroo Apple and, in the ground flora, Spiny-headed Mat-rush, Thatch Saw-sedge, Hop Goodenia, Slender Speedwell, Matted Pratia and Prickly Starwort. Flowering amongst sedges are colonies of Austral Leek-orchid.

The yearly peak of rainfall usually occurs during True Spring and this pushes the **River** into massive fluvial flows, submerging river islands, force feeding bill-abongs and wetlands on the Yarra Flats of the Chandler basin. Assisted by the snow thaw in the ranges around Mount Baw Baw, the river has the power to carve new rivershapes into the alluvial soils of the Yarra Flats, creating billabongs, although the damming of the upper reaches lessens the likelihood of new billabongs forming in the future.

Wetlands are pumping productivity levels towards their peak with growing and flowering flushes of many wetland plants such as Leafy Flat Sedge, River Clubrush, Tall Sedge, and Water-ribbons. Water Spiders skate across the water surface aerially patrolled by Dragonflies and Damselflies that are emerging. Egg clusters of the second Lacewing layings are found on the litter and vegetation around the littoral along with eggs of Striped Marsh Frogs. Tadpoles which have diversely developed appendages share the pools with a wide variety of invertebrates including Water Fleas, Water Pennies, Mayflies, Caddisflies and Water Boatmen which produce a teeming abundance of pond life. Food aplenty for growing ducklings and chicks of Dusky Moorhens, Purple Swamphen, and Eurasian Coot.

Tiger Snakes make their presence obvious in a short period of visibility during a fortnight or so of breeding activities early in True Spring. This sudden deluge of sightings often panics users of urban Parks, such as Westerfolds, into reptilian phobias of an exaggerated scale.

Migrants, Clamorous Reed-Warblers call from the branches of introduced Cumbungi, and White-winged Trillers are busy nest building. In the Plenty Gorge Parklands, Rainbow Birds inspect bluestone tailings mounds for possible nest

sites. Lathams Snipe have returned from Japan, occasionally being killed by hitting the high voltage wires strung along Yarra Flats Park over the Wetlands. Resident Cattle Egrets in breeding plumage feed on open fields of pasture grasses, perhaps on the huge number of young Black Field Crickets that are flooded from the ground during heavy rains. A Golden-headed Cisticola perched on the tall growing introduced Toowoomba Canary-grass warns off passing pedestrians with vigorous and angry vocalisations.

In a cool **Gully**, the Wonga Vine finds refuge and flowers as does Austral Clematis. Migratory birds, such as the Rufous Fantail which has returned to the same nesting site after migrating from New Guinea, the melodious Rufous Songlark and the Leaden Flycatcher, often use these sheltered sites to nest. In search of the dome nests of birds such as Warblers, Scrubwrens and Thornbills to parasitise, is the Golden Bronze-cuckoo. Immature Fan-tailed Cuckoos are already about, having gluttonously dominated the offerings of other's parents. Mistletoebirds collect fruit from Box Mistletoe growing on a flowering Narrow-leaf Peppermint. Rarely observed in the Middle Yarra, a Copperhead Snake makes its way past a Tall Daisy in flower amidst a stand of Maidenhair Fern beginning to desiccate. Mosses also dry out during the later stages of True Spring. Ringtail Possums begin to wean their young, some of which fall from the mothers back to be rescued by Wildlife Care network.

Across the **Valley Woodlands,** a broad spectrum of the species-rich flora, are in bloom - Common Buttercup, Candles, Milkmaids, Bulbine Lily, Twining Fringe-lily, Chocolate Lily, Hop Bitter-pea, Creeping Bossiaea, Common Rice Flower, Austral Bears Ears, Shiny Cassinia, Grey Everlasting, Trailing Goodenia, Spur Velleia, Purple Violet and Grey Guinea-flower are some of the plants colouring the ground flora. Black Wattle rounds off the Spring flowering season with its usual prodigious flowering throughout a range of vegetation communities.

True Spring is the season to see a great range of Orchids such as Purplish Beard-orchid, Rusty Greenhood, Bearded

Greenhood, Green Comb Spider, Dotted Sun Orchid, Salmon Sun Orchid, Common Bird Orchid, Cinnamon Bells, and on hot, still October days of perfect True spring weather, Slender Sun Orchids come out in their thousands.

Magpie and Grapevine Moths are busy over their food plants, and Termites are in flight during humid weather. Jewel Spiders are a common sight as are clusters of Sawfly larvae, but it is the Butterflies that seem to dominate the hot blue skies. Imperial White, Australian Admiral, Painted Lady, Spotted Skipper, Lesser Wanderer, Common Grass Blue, Common Dusky Blue, Woodwhite, Symmomus Skipper, Yellow-banded Dart and the Common Brown all bring colour and movement of heavenly proportions.

Exotic Grasses are in full anthesis and the air is full of pollen (much to the discomfit of Hayfever sufferers). The mixture of fragrances is heady and intoxicating, and imbues the Season with one of its most enduring dimensions - the smell of Spring. It stimulates the soul as well as the sinuses. Native Grasses are also growing strongly and sending up flowering culms to join in the riot of pollen on the wind.

Young Rabbits are prolific and provide food for young Red Foxes, in what seems an unbroken food web imported from Europe. Mudlarks have fledgelings which never seem to fall out of nests with the same frequency as young Magpies. King Parrots pass through the Middle Yarra Valley and Short-beaked Echidnas are often observed on long treks across their country, sometimes through backyards of the urban/rural fringe. Blue Bottle Wasps, the female an iridescent blue, are also regularly observed on the hot days of True Spring clambering along the ground awaiting the male to lift her to the skies in the nuptial flight.

On **Hilltops** more Orchids are on show - Alpine Greenhood, Leopard Orchid, Tiger Orchid, Donkey Orchid and Brown Beaks, and Native Flax, Button Everlasting, Yam Daisy, Grass Trigger-plant, Common Apple Berry, Blue Pincushion and Sticky Everlasting add to the riot of floral embellishments on the ground. On some north facing **Escarpments** in Warrandyte, Plum-leaf Pomaderris has spectacular dis-

plays of its golden flowers.

Warm weather stimulates Mole Crickets and Field Crickets to call at dusk. **Night** brings out Emperor Gum Moth, Red-lined Geometrid, Green-blotched Moth and the Granny Moth under skies dominated by the stars Altair, Hamal, Achernar, Lyra and Canopus. If unusually strong northerly winds prevail during the migration of Bogong Moths to the Mountain tops of the Australian Alps, there may be large influxes of this moth into Melbourne.

Sometimes the Powerful Owl is heard calling strongly but it is the almost querulous sounding conversation of the Willie Wagtail carried out on balmy True Spring evenings, that captures my imagination as I wonder what Timelonic observations are being made from the nest at the bottom of the Garden.

Acknowledgements

Animal List

Echidna, Short-beaked *Tachyglossus aculeatus*
Fox, Red *Canis vulpes*
Rabbit, European *Oryctolapus cuniculus*
Platypus *Ornithorhynchus anatinus*

Bee-eater, Rainbow *Merops ornatus*
Bronze-cuckoo, Golden *Chrysococcyx lucidus plagosus*
Bronze-wing Pigeon, Common *Phaps chalcoptera*
Cisticola, Golden-headed *Cisticola exilis*
Coot, Eurasian *Fulica atra*
Cuckoo, Fan-tailed *Cacomantis flabelliformis*
Egret, Cattle *Ardea ibis*
Fantail, Rufous *Rhipidura rufifrons*
Flycatcher, Leaden *Myiagra rubecula*
Flycatcher, Satin *Myiagra cyanoleuca*
Kingfisher *Todiramphus sanctus*
Magpie, Australian *Gymnorhina tibicen*
Magpie-lark, Australian *Grallina cyanoleuca*
Mistletoebird *Dicaeum hirundinaceum*
Moorhen, Dusky *Gallinula tenebrosa*
Owl, Powerful *Ninox strenua*
Parrot, Australian King *Alisterus scapularis*
Reed-Warbler, Clamorous *Acrocephalus stentoreus*
Rosella, Eastern *Platycercus eximius*
Snipe, Lathams *Gallinago hardwickii*
Songlark, Rufous *Cinclorhamphus mathewsi*
Swamphen, Purple *Porphyrio porphyrio*
Triller, White-winged *Lalage sueurii*
Wagtail, Willie *Rhipidura leucophrys*
Wattlebird, Red *Anthochaera carunculata*
Whistler, Rufous *Pachycephala rufiventris*
Woodswallow, Dusky *Artamus cyanopterus*

Snake, Copperhead *Austrelaps superbus*
Snake, Tiger *Notechis scutatus*

Galaxia, Common *Galaxias maculatus*
Galaxia, Spotted *Galaxias truttaceus*
Grayling, Australian *Prototroctes maraena*
Tupong, *Psuedaphritis urvillii*

Frog, Striped Marsh *Limnodynastes peroni*

Admiral, Australian *Vanessa itea*

Blue, Common Dusky *Candalides hyacinthinus*
Blue, Common Grass *Zizina labradus*
Brown, Common *Heteronympha merope*
Cricket, Black Field *Gryllus servillei*
Dart, Yellow-banded *Ocybadistes walkeri*
Flea, Water *Cladocera* sp.
Geometrid, Red-lined *Crypsiphona ocultaria*
Mayflies *Tasmanocoenis* sp.
Moth, Bogong *Agrostis infusa*
Moth, Emperor Gum *Opodiphthera eucalypti*
Moth, Granny *Dasypodia selenophora*
Moth, Grapevine *Phalaenoides glycinae*
Moth, Green-blotched *Cosmodes elegans*
Moth, Magpie *Nyctemera amica*
Painted Lady *Vanessa kershawi*
Pennies, Water *Sclerocyphon* sp.
Skipper, Spotted *Hesperilla ornata*
Skipper, Symmomus *Trapezites symmomus*
Spider, Water *Dolomedes* sp.
Wanderer, Lesser *Danaus chrysippus*
Water Boatman *Micronectas* sp
White, Imperial *Delias harpalyce*

PLANT LIST

Bird Orchid, Common *Chiloglottis valida*
Canary-grass, Toowoomba *Phalaris aquatica*
Club-rush, River *Schoenoplectus validus*
Flax, Native *Linum marginale*
Fringe-lily, Twining *Thyanotus patersonii*
Greenhood, Alpine *Pterostylis alpina*
Greenhood, Bearded *Pterostylis plumosa*
Greenhood, Rusty *Pterostylis rufa*
Leek-orchid, Austral *Prasophyllum australe.*
Lily, Bulbine *Bulbine bulbosa*
Lily, Chocolate *Athropodium strictum*
Maidenhair Fern *Adiatum aethiopicum*
Orchid, Donkey *Diuris corymbosa*
Orchid, Green Comb Spider *Caladenia dilatata*
Orchid, Leopard *Diuris pardina*
Orchid, Purple Beard *Calochilus robertsonii*
Orchid, Tiger *Diuris sulphurea*

Saw-sedge, Thatch *Gahnia radula*
Sedge, Leafy Flat *Cyperus lucidust*
Sedge, Tall *Carrex appressa*
Sun-Orchid, Salmon *Thelymitra rubra*
Sun-orchid, Slender *Thelymitra pauciflora*
Water-ribbons *Triglochin procerum*

Apple Berry, Common *Billardiera scandens*
Bears Ear, Austral *Cymbonotus lawsonianus*
Bells, Cinamon *Gastrodia sesamoides*
Bitter-pea, Hop *Daviesia latifolia*
Bossiaea, Creeping *Bossiaea prostrata*
Bottlebrush, River *Callistemon sieberi*
Brown Beaks *Lyperanthus suaveolens*
Burgan *Kunzea ericoides*
Bush, Hemp *Gynatrix pulchella*
Buttercup, Common *Ranunculus lappaceus*
Cassinia, Shinny *Cassina longifolia*
Clematis, Austral *Clematis aristata*
Candles *Stackhousia monogyna*
Christmas Bush *Prostanthera lasianthus*
Cumbungi *Typha latifolia*
Daisy-bush, Snowy *Oleria lirata*
Daisy, Tall *Brachyscome diversifolia*
Daisy, Yam *Microseris lanceolata*
Everlasting, Button *Helichrysum scorpioides*
Everlasting, Grey *Ozothamnus obcordatus*
Everlasting, Sticky *Bracteantha viscosa*
Goodenia, Trailing *Goodenia lanata*
Guinea-flower, Grey *Hibbertia obtusifolia*
Gums, Manna *Eucalyptus viminalis*
Kangaroo Apple, Large *Solanum laciniatum*
Milkmaids *Burchardia umbellata*
Mistletoe, Box *Amyema miquelii*
Paperbark, Swamp *Melaleuca encifolia*
Peppermint, Narrow-laef *Eucalyptus radiata*
Pincushion, Blue *Brunonia australis*
Pomaderris Plum-leaf *Pomaderris prunifolia*
Pratia, Matted *Pratia pedunculata*
Prickly Moses *Acacia verticillata*
Rice Flower, Common *Pimelea humilis*
Speedwell, Slender *Veronica gracilis*
Starwort, Prickly *Stellaria pungens*
Trigger-plant, Grass *Stylidium graminifolium*
Velleia, Spur *Velleia paradoxa*
Violet, Purple *Viola betonicifolia*
Vine, Wonga *Pandorea pandorana*

Falkinham, Ed Grey, Pat Grey, Neil McKinnon, Alan Reid, John Reid, Elizabeth Seviour, Ken Simpson, Vin Pettigrove (Melbourne Water), Alan Yen (Museum of Victoria) the Middle Yarra Timelines Committee and all who have contributed to the data bank of information for the Project so far.

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Naturalist

F.N.C.V.

Volume 114 (2) 1997 April

Naturalist in Residence

The editors wish to thank Glen Jameson for his much appreciated series of articles on the 'Timelines of the Middle Yarra' - thank you Glen.
We also welcome Ian Endersby as the current 'Naturalist in Residence'. The first of his articles appears in this issue.

Books Available from FNCV

The Club has, over the years, published a number of books on natural history topics which can be purchased from the Book Sales Officer. It is currently distributing five, as follows:

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If ordering two or more books, total postage is $6.50. Full details in the April *Field Nat News*.

Erratum

In *The Victorian Naturalist* **113** (6) 1996, 318, the article on Dr Sophie Ducker stated that 'her father had been born in Schleswig-Holstein, Mueller's birthplace also.' Dr Ducker has pointed out that it was, in fact, her husband who was born there.

We apologise for this error.

The Victorian Naturalist

Index to Volume 113, 1996 is in the centre of this issue

Cover: The Bush Rat *Rattus fuscipes*, see article on page 52. Photo courtesy P. R. Bird

Mammals and Birds of the Mount Napier State Park

P.R. Bird[1]

Abstract

This paper reports observations made over twenty years (1974-95) in Mt. Napier State Park, an area of newer volcanics dominated by Manna Gum *Eucalyptus viminalis*, Blackwood *Acacia melanoxylon*, Austral Bracken *Pteridium esculentum* and Common Tussock Grass *Poa labillardieri*. The Dusky Antechinus *Antechinus swainsonii* and Bush Rat *Rattus fuscipes* were the most common small native mammals captured. The Brown Antechinus *A. stuartii* and Swamp Rat *R. lutreolus* were less common. A Brush-tailed Phascogale *Phascogale tapoatafa* and Sugar Glider *Petaurus breviceps* were seen in the forest. The most common bats caught were Chocolate Wattled Bat (*Chalinolobus morio*), Lesser Long-eared Bat *Nyctophilus geoffroyi* and Little Forest Bat *Vespadelus vulturnus*. The least common bats were Gould's Wattled Bat *C. gouldii*, Gould's Long-eared Bat *N. gouldi*, Large Forest Bat *V. darlingtoni* and Southern Forest Bat *V. regulus*. Common Bent-wing Bats *Miniopterus schreibersii* also roost in the Byaduk Caves. Significant bird records were Rose Robin *Petroica rosea*, Satin Flycatcher *Myiagra cyanoleuca*, Black Falcon *Falco subniger* and Grey Goshawk *Falco hypoleucos*. (*The Victorian Naturalist* 1997, **114**, 52-66).

Introduction

The Mt. Napier State Park lies 13 km south of Hamilton in south west Victoria (Fig. 1). The park occupies some 3,000 ha of volcanic landscape of comparatively recent origin. The dominant feature of the landscape is a scoria cone named Mt. Napier in 1838 by Major Thomas Mitchell. In May 1841, G.A. Robinson camped at a village of the powerful Tappoc Conedeet clan at 'the great swamp' (now the drained Buckley Swamp), before they were dispossessed of the country, and learned that their name for the cone nearby was Tappoc (Presland 1977). The volcano erupted at least 7,300 years ago (Gill and Elmore 1973), covering about 9,000 ha of the extensive but thin sheet of Pliocene basalt, which overlies Cainozoic marine sediments. Willis (1963) provides notes on the history and vegetation of the former small Mt. Napier Reserve. The geological features of the surrounding area and the Byaduk lava caves are described by Gill and Elmore (1974) and Ollier and Brown (1964), respectively.

The soils of the area are fertile but mostly stony and most of the area outside the park has, with great difficulty, been used for agriculture. Crown land was sold in the area through to the 1960s. The remainder, including a Forest Reserve in the northern sector, was locally regarded as 'wasteland'. Scoria was mined at Menzel's Pit. Much of the land in the southern and western sectors was leased for grazing up until at least 1980. There is no surface water on

the newer basalt within the park.

State Park status was recommended by the Land Conservation Council in 1982, and proclaimed by the government several years later. A draft management plan was prepared in 1990 but has yet to be released.

The vegetation varies from grassy woodland to tall open forest. Manna Gum *Eucalyptus viminalis* is the sole eucalypt and the dominant tree species. Blackwood *Acacia melanoxylon*, Cherry Ballart *Exocarpos cupressiformis* and Tree Everlasting *Ozothamnus ferrugineus* are the major understorey trees. Apart from the Byaduk Caves on the Harman's Valley lava flow, Black Wattle *A. mearnsii* is restricted mainly to the margins of the new lava and in a few 'islands' where the older basalt soils were not covered. Swamp Gum *E. ovata* is only found on freehold land just off the newer basalt. Shrubs such as Sweet Bursaria *Bursaria spinosa*, Kangaroo Apple *Solanum laciniatum* are widespread, while Sticky Boobialla *Myoporum viscosum*, Western Golden-tip *Goodia medicaginea* and Shiny Cassinia *Cassinia longifolia* are less common.

An aerial photograph from 1948 shows no trees on the summit and few on the mid and upper slopes of the Mount, consistent with the disastrous Jan 1944 fires which swept the district. Willis (1963) commented on the fire-damaged vegetation on the Mount. The forest has been regularly burned by graziers and arsonists. Lightning has not been a factor here. Severe fires in Nov 1965, Easter 1972, Sep 1977, Oct 1975, Dec 1980 and Oct 1987 were noted in Department files or by the local press.

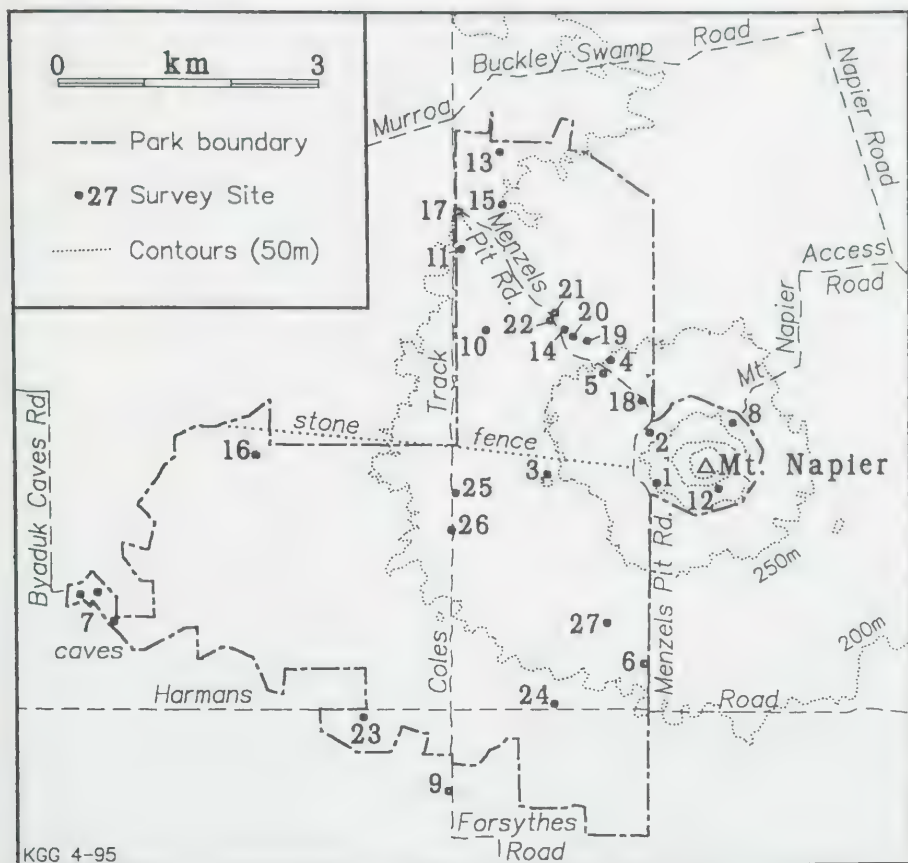[1] Private Bag 105, Hamilton, Victoria 3300.

Fig. 1. Mt Napier State Park and mammal survey sites.

Smaller fires in Sep 1994 and May 1996 were also 'deliberately lit' (Anon 1994, 1996).

Fires have severely modified the vegetation. Blackwoods are common and widespread in the park but mature specimens are rare because few manage to survive beyond one or two fire cycles. The northern flank of the Mount is the only area in the park that has not been burned since 1972 and Blackwoods there stand some chance of achieving old age. Here the trees also appear to have suppressed the undergrowth.

Fires kill all young trees in areas of tall, thick bracken growing on deep brown soil near the lava 'barriers', and damage mature Manna Gums. Blackwoods and young Manna Gums struggle in this deep-soil zone that should otherwise provide the best growth. The park managers have not taken adequate account of ecological factors here and an ill-advised prescribed burn

in April 1993 near Murroa Corner scorched foliage to 10 m height and killed most of the young trees, severely degrading the tourist route to the Mount.

Austral Bracken *Pteridium esculentum* is the dominant groundcover species in most areas of the park. The presence of long stone fences throughout the forest, now in parts so dense with Austral Bracken as to scarcely admit passage, shows that this was not always so. Bruni (G.A. Browne) confirms this in an article written in 1903 ... 'many years ago the brackens began to spread throughout the stony country and in a short time they completely covered the surface, to the great detriment of the pasture... the stony rises used of old to fatten cattle splendidly'. Much of the forest, too, had been changed since it was held under squatting license... 'in the stony country surrounding Mt. Napier, as elsewhere, the

Table 1. Mammal survey sites in the Mt. Napier State Park (see Fig. 1)

1. Mt. Napier Reserve, SW corner, on Menzel's Pit Rd, 2.7 km N from Harman's Rd; Manna Gum and Blackwood woodland with tussocks. Burned Easter 1972 and in Sep 1977.
2. Mt. Napier Reserve, NW corner, 0.3 km S from Menzel's Pit; small cone with lava blocks, logs, bracken, tussocks and Black - wood. Burned in 1972 and in 1977.
3. Elmore's Cone with lava bridge and collapsed tunnel, 0.25 km S of the E-W stone fence from a point 1 km W from the junction of that fence with Menzel's Pit Rd; tall open forest with tall bracken and tussocks. Burned in Nov 1965 and early 1970s.
4. Scoria cone 0.1 km E of Menzel's Pit Rd from a point 0.7 km N of Menzels Pit; grassy Manna Gum woodland with a few logs. Burned in 1972.
5. Barrier and crater W of Menzel's Pit Rd, opposite Site 4; tussocks and old trees on barrier, dense bracken in crater. Burned in 1972 and on 28 Sep 1977.
6. Barrier edge, W side of Menzel's Pit Rd, 0.5 km N from Harman's Rd; dense bracken and scattered Manna Gums. Burned in the early 1970s and late 1970s.
7. Byaduk Caves (Harman's 1 and 2, Bridge, Brown's and Church caves); dense bracken, other ferns, Shiny Cassinia and a few Blackwoods.
8. Mt. Napier Reserve, NE corner; dense tussocks, Variable Groundsel, bracken, young open forest of Blackwood and Manna Gums. Burned in 1972.
9. Forsythe's Rd, 1 km S of Harman's Rd; barrier with logs, Manna Gums, bracken and a grassy clearing with Black Wattles. Burned in the early 1970s.
10. Barrier edge, 0.5 km E of Cole's Tk from a point 2.5 km from Murroa Corner; Sticky Boobialla, Sweet Bursaria, bracken and logs. Burned in 1972 and in 1975.
11. Along Cole's Tk, 1-2 km from Murroa Corner; old open forest of Manna Gum, Blackwood, Tree Everlasting, tussocks and bracken. Parts burned in Oct 1975.
12. Mt. Napier Reserve; moist gully on the SE flank, tall open forest of Manna Gum, with Mother Shield-fern, bracken and tussocks. Burned in 1972.
13. Open forest near a barrier, 0.5 km E of Menzel's Pit Rd from a point 0.5 km from Murroa Corner; Manna Gums and dense bracken. Burned in 1972 and 31 Dec 1980.
14. Menzel's Pit Rd, 3 km from Murroa Corner; lava rock pile, bracken and tussocks on the E side of the track. Burned in 1972.
15. Open forest near a barrier, 0.5 km E of Menzel's Pit Rd from a point 1 km S from Murroa Corner; tall Manna Gums and dense bracken. Burned in 1972.
16. Edge of barrier 0.7 km S of the stone fence at the "Old Ruin", E of Byaduk Caves; tall open forest of Manna Gum, with tussocks and bracken. Burned in 1972.
17. Between the junction of Cole's Tk and Menzel's Pit Rd; open Manna Gum forest adjoining a grassy, bracken-clad barrier. Burned in 1972.
18. Menzel's Pit, 4.5 km along Menzel's Pit Rd from Murroa Corner; scoria boulders amidst Kangaroo Apple, bracken and Manna Gums. Burned in 1972 and 1975.
19. A patch of Manna Gum, bracken and Bidgee Widgee not burned Sep 1977; 0.2 km E of a quarried cone on Menzel's Pit Rd from a point 3.3 km from Murroa Corner.
20. A 1 ha patch of rocks and logs in a stony basin not burned in Sep 1977; 0.1 km E of Menzel's Pit Rd from a point 3 km from Murroa Corner.
21. Several small patches of tall, old Manna Gums amidst stony ridges not burned in Sep 1977; just E of Menzel's Pit Rd, from a point 2.75 km from Murroa Corner.
22. Small patch (0.2 ha) of dense bracken and tussocks unburned in Oct 1975; W of Menzel's Pit Rd opposite Site 21, adjacent to a barrier.
23. A ridge of lava with sparse Manna Gums and moderately tall bracken, not burned in 1975; 0.1 km S of Harman's Rd from a point 0.4 km E of the edge of the lava field.
24. Patch of jumbled lava, tussocks and old Manna Gums, not burned in Sep 1977; N side of Harman's Rd, 1.1 km W of junction of Harman's Rd and Menzel's Pit Rd.
25. Woodland along E side of Cole's Tk, 0.5 km S from the E-W stone fence; tall bracken running on to sparsely clad ridges. Burned in 1965 and in 1975.
26. Open forest along W side of Cole's Tk, 1.0 km S from the E-W stone fence; rough lava with large Manna Gums, deep bracken and tussocks. Burned in 1965 and in 1975.
27. Hill in forest 0.5 km W of Menzel's Pit Rd, from a point 1 km N of Harman's Rd.

timber has been cleared away 'til it is almost a plain and the once heavily wooded mount has become a bald hill'. Mitchell had cleared the summit of trees in 1836 (Mitchell 1838); nearly 150 years later the Hamilton Field Naturalists began to replant it with trees grown from seed collected at the base of the Mount. The dominance of

Austral Bracken in the park is probably due to the increased frequency of fire, together with the impact of grazing by rabbits and livestock on other species.

Common Tussock Grass *Poa labillardieri* is conspicuous on the stony barriers and the slopes of the mount. Bidgee Widgee *Acaena anserinifolium* is also widespread.

Variable Groundsel *Senecio lautus*. Small-leaved Clematis *Clematis microphylla*, Austral Storks-bill *Pelargonium australe*, Bluebells *Wahlenbergia* spp. and Ivy-leaf Violet *Viola hederacea* are conspicuous groundcover species, providing a showy display in the summer.

The total number of native vascular species recorded for the area, including the Byaduk caves (Beauglehole and Learmonth 1957) and the former Mt. Napier Reserve (Willis 1963), is only 176 species (records of Beauglehole (1984) and a few recent additions by Elmore and Bird). There are a further 102 alien species.

This report provides an assessment of the mammal and bird species living in the forest area, which has been isolated from other forest areas for over a hundred years due to the clearing of the surrounding plain for farms. No surveys of this area have been previously made, although Emison *et al.* (1978) surveyed a geologically similar area 25 km further south (the former Stones State Faunal Reserve and Mt. Eccles National Park).

Methods

The observations recorded in this paper have been made sporadically between 1974 and 1995. The survey sites are described in Table 1 and their location indicated in Fig. 1.

Several mammal survey methods were used, under permits from the former Fisheries and Wildlife Division, Ministry of Conservation Victoria:

1. Live trapping.

(a) Cage traps - 10 traps (45 x 15 x 12.5 cm) were made from wire mesh (1.25 x 1.25 cm) and 10 cylindrical traps (30 x 9 cm diameter) were made from wire mesh (2.5 x 2.5 mm); the large cage traps did not retain mice or very small *Antechinus*. Twenty small and 10 large Elliott aluminium traps were also employed after 1979. Traps were baited with a mixture of honey, peanut butter and rolled oats. The traps were set on the ground, except for one period (Site 13) when 10 mesh traps were set 5 m up trees for three nights. Traps were checked each morning and, when they were to be left for more than one day, occasionally in the late afternoon. Captured mammals were put in a small bag and weighed on a Salter 250 g spring balance to the nearest gram. The animals were then measured with respect to head-body length, tail length, length of hind foot (excluding nail), length of ear from the notch, foreclaw and hindclaw (*Antechinus* spp. only). A vernier calliper and graduated ruler were used. One specimen of each species was retained and lodged either with the former Fisheries and Wildlife Division or the former National Museum of Victoria (NMV) for reference. Other animals were released at the site of capture, after clipping a toenail to enable a recaptured animal to be identified.

(b) Pit traps - 4 pit traps (a 20 L drum set just below the ground level) were set at approximately 5 m spacing at each of Site 1 (grassland) and Site 17 (bracken dominated understorey) and a 20 x 0.3 m polythene barrier was erected across the centre of the drums. The lines were monitored daily from 1-5 Jan 1979.

(c) Bat traps - 2 collapsible harp traps were constructed along the lines of that described by Tidemann and Woodside (1978), except that the frame was made from wood rather than aluminium. Cords were slung over convenient vantage points (usually branches) and the frame was lifted into position from hooks attached to the top corners. Sites were chosen where a trap could cover a substantial part of a flight path through the trees or entrance to a lava tunnel. The traps were set at dusk and checked early in the morning. Most bats were weighed, length of ear and forearm recorded and colour of fur noted to aid identification (Hall and Richards 1979). The first male of each species was retained and lodged with the NMV for reference; all other bats were released at the site of capture. Pregnant females bearing single or twin foetuses were noted.

2. Predator scat analysis.

Scats, presumably from Red Foxes *Vulpes vulpes*, were collected along the tracks in the forest and at the Byaduk Caves. The scats were prepared as described by Brunner *et al.* (1975) and examined microscopically by Hans Brunner, Keith Turnbull Research Institute, Frankston.

Bone material was also collected from the soil or rock floors of caves in the forest at The Bridge (Oct 1973), SW of Mt. Napier (June 1977), and Brown's Cave at the Byaduk Caves (June 1977) and identified by Joan Dixon, Curator of Mammals (NMV).

Table 2. Number and species of mammal captured in the Mt. Napier forest
Key: () = Number of animals recaptured indicated in brackets

Site	Number of Trap Nights	Antechinus Dusky	Antechinus Brown	Rat Bush	Rat Swamp	Rat Black	Mouse House
1	108	-	-	-	-	-	1
2	55	6	1	2	-	-	1
3	120	1	-	-	2	2	22
4	50	-	-	-	-	-	14
5	123	6	1	25(6)	-	-	4
6	80	9(2)	-	-	2	1	3
7	36	1	-	-	-	6	1
8	50	-	-	-	5	2	5
9	68	6	-	-	-	-	1
10	18	4	-	-	-	1	-
11	122	3	-	2	-	-	3
12	60	2	-	1	2	-	1
13	194	3	14	13(1)	-	-	5
14	56	1	-	1	-	-	-
15	46	5	-	3(1)	2	-	-
16	60	5	-	4	-	-	3
17	82	-	2	-	1	-	5
18	28	2	-	8	-	-	1
19	12	3	-	-	-	-	-
20	8	1	-	-	-	-	-
21	16	1	-	1	-	-	-
22	16	-	-	2(1)	-	-	-
23	20	-	1	1	-	-	-
24	20	-	-	-	-	-	2
25	30	-	-	-	-	-	-
26	60	7	-	-	-	-	-
Total	**1538**	**66(2)**	**19**	**63(9)**	**14**	**12**	**72**

3. Hair sampling tubes.

Twenty hair-sampling tubes were constructed according to the design of Suckling (1978). Bait was smeared on the inside centre of the tubes which were then nailed to tree trunks 2-4 m from the ground. The tubes were sampled for 2 weeks in July 1978.

4. Nest boxes.

Ten wooden boxes (five were 30 x 10 x 10 cm and five were 40 x 15 x 15 cm) were tied to trees 4-5 m from the ground. The small boxes had entry holes of 40 mm diameter and the larger boxes 60 mm diameter, which were situated towards the top of the box. Each had a detachable lid to allow inspection inside. The boxes were installed in January 1980 and inspected in Feb, April and Oct 1980, April and July 1981. Four were destroyed by fire in Dec 1980.

5. Daylight and spotlight observation.

Sightings of birds and mammals in daylight were recorded while carrying out survey methods 1-4 above. Spotlight observations of mammals and nocturnal birds were made on twelve occasions from a vehicle and on foot.

6. Survey of historical literature.

Changes in flora and mammalian fauna over time were assessed by reference to historical literature (*e.g.* Bruni 1903, Mitchell 1838, Presland 1977 and 1980, WW 1916), including the local press, recollections of adjoining landholders and sub-fossil records for the Byaduk Caves (Wakefield 1964).

Results

The mammals captured in cages and Elliott traps within the forest are shown in Table 2. Overall, there were 246 captures (including 11 recaptures) in 1538 trapnights (16% success). The total for natives was 162 captures (11% success). Some unexpected captures were four skinks (*Sphenomorphus* sp.) and, when several traps were set in trees, two White-throated Treecreepers and a Brown Thornbill.

Two species of *Antechinus* and two native *Rattus* species were found, together with two species of introduced rodent. The Dusky Antechinus *Antechinus swainsonii*, 64 individuals, and Bush Rat *R. fuscipes*, 55 individuals, were the most common small native mammals captured in the Park. The Brown Antechinus *A. stuartii* occurred irregularly, in time and space. The percentage of males in the captured

Table 3. Numbers and species of bats captured within the Mt. Napier forest.
The data for mass and forearm include mean, standard deviation (sd) and number of observations (n)
Key: 1 = number trapped; 2 = mass (g), mean ± sd (n); 3 = Forearm (mm) mean ± sd (n); 4 = Forearm range (mm)

Species	1	2	3	4
Bat, Gould's Wattled *Chalinolobus gouldii*	1		48.0	
Bat, Chocolate Wattled *Chalinolobus morio*	70	10.5 ± 1.2 (43)	38.5 ± 1.0 (61)	36.4-41.0
Bat, Lesser Long-eared *Nyctophilus geoffroyi*	32	8.6 ± 1.7 (14)	37.5 ± 1.2 (20)	36.0-39.0
Bat, Gould's Long-eared *Nyctophilus gouldi*	5	10.6 ± 1.1 (5)	41.5 ± 1.4 (5)	40.0-43.0
Bat, Large Forest *Vespadelus darlingtoni*	3	7.0 ± 0 (3)	34.3 ± 0.6 (3)	34.0-35.0
Bat, Little Forest *Vespadelus vulturnus*	22	4.5 ± 1.3 (4)	28.8 ± 0.9 (16)	26.6-30.0
Bat, Southern Forest *Vespadelus regulus*	1	6.0	31.6	

Dusky Antechinus, Brown Antechinus, Bush Rat and Swamp Rat *R. lutreolus* was 58, 37, 50 and 57%, respectively.

Trapping was usually directed to areas that had not been recently burned, sometimes islands of unburned vegetation. However, there were a few occasions when burned areas were targeted. Three Bush Rats were caught in Oct 1977, below the rim of a lava flow burned 10 days earlier. In March 1978, no rats were caught in this area of vigorous Austral Bracken regrowth but one animal was trapped amidst Common Tussock Grass in a nearby copse of Blackwood. In April 1976, no animals were caught at Site 11 on patches which had been burned for fuel reduction in Oct 1975, but three animals were caught in the unburnt sections.

The earliest evidence of breeding in the Dusky Antechinus was July; one female was found on the 31 July 1976 with eight young attached to teats. Since the offspring were 1-1.5 cm in length, perhaps they were born two weeks earlier. The three smallest independent animals were trapped in mid October and weighed 12, 15 and 18 g. Lactating females were found as late as 2 November. Only one Brown Antechinus was found to be lactating; this female was caught on 22 October. The smallest animals, four females each weighing 16 g, were caught in April.

No mammals were captured in pit traps.

Seven species of bats were captured in the harp traps and data for body mass and forearm length is presented in Table 3. Of the 33 trap nights, made over 10 different periods of 1-7 days between April 1979 and Jan 1987, 134 bats were captured. Most bats were caught in the months November to January. In Nov of 1979 and 1986, most of the females were pregnant. Both of the female Little Forest Bats captured had a single young; 26 of the 28 female Chocolate Wattled Bats captured had twins and two had single young; all nine of the female Lesser Long-eared Bats and both female Gould's Long-eared Bats had twins.

When this survey began the *Vespadelus* (formerly *Eptesicus*) group had not been differentiated and it is possible that some bats recorded then as *V. vulturnus* (Little Forest Bat) may have been *V. regulus* (Southern Forest Bat), because both species are similar in appearance (Hall and Richards 1979) and the range of forearm and other measurements overlap. Kitchener *et al.* (1987) give a range of 26.3-32.8 mm for *V. vulturnus* and 28.0-34.4 mm for *V. regulus*. In particular, one bat recorded in 1987 as a Little Forest Bat has been ascribed in Table 3 as a Southern Forest Bat. The bat was lodged with NMV but can not be located. However, from notes on the specimen - male, forearm 31.6 mm, body 41 mm, tail 35 mm, tragus 6 mm, ear 11 mm, colour and characteristic penis shape (Kitchener *et al.* 1987) - it was probably *V. regulus*.

Seven mammal species were detected by predator scat analysis (Table 4). Many of the scats collected in April and May of 1978 consisted almost entirely of insect remnants (mainly crickets and moths). Two samples collected from caves were from owl or kestrel pellets of recent origin. Other bone samples of uncertain age were also collected from the lava caves (Table 5) and might best be described as sub-fossil.

No small mammals were detected using hair sampling tubes, but hairs of Common Brushtail Possum were found in two tubes which had been disturbed.

Five native and five alien mammal species not detected by other means were seen by spotlight or during the day (Table 6). Only one Eastern Grey Kangaroo and no Swamp Wallabies were seen before 1986, despite 19 hours of spotlighting and

Table 4. Species of mammal detected within the Mt. Napier forest area by analysis of fox scats collected along tracks from June-Aug 1977 and April-June 1978. The data shows the number of scat samples containing a particular species.
Key: Site = site number; No = number of samples;
A = Rat, Bush; B = Antechinus, Brown; C = Echidna; D = Possum, Common Brushtail; E = Sheep; F = Rabbit; G = Mouse, House; # one scat containing Common Brushtail Possum fur also had a lead shot-gun pellet; another scat contained Crimson Rosella feathers.

Site	No	A	B	C	D	E	F	G
7	29	1	-	1	-	-	26	6
6-18	24	-	-	-	2		24	-
23-24	15	-	-	2	2	-	14	-
17-18	41#	2	4	2	6	4	34	-
TOTAL	109	3	4	5	10	4	98	6

conducting the entire cage trapping, scat collection and most of the bat survey work in that period. Only one Echidna was seen, despite plentiful evidence of digging and appearance of quills in fox scats.

Birds recorded in the survey area are shown in Table 7, where an indication of the habitat distribution of the birds - forest, grassland, temporarily flooded areas or aerial nomads - is given. Species seen only once are also marked.

Body measurements (mean, range and standard deviation) for captured *Antechinus* and native *Rattus* species are presented in the Appendix (Table 8) in order to characterise these populations. The effect of body mass (a surrogate for age) on the proportions of some body components is examined from the relationships between body mass and various linear body measurements (Table 9).

Discussion
The most common bat captured was the Chocolate Wattled Bat. Most of the bats captured in harp traps placed across the entrances to the small caves in the forest in Nov 1986 were females and most were heavily pregnant, with most of the Chocolate Wattled Bats carrying twins. Similar numbers of this species were found at this site in Dec 1980, but none were obviously pregnant. Since pregnant females were noted in Nov 1979 it seems probable that in 1980 all had given birth by late December. This is not invariable because in Jan 1986 one of five females was still carrying a single foetus.

Since most bats of all species, except Gould's Wattled Bat and Southern Forest Bat, were caught entering or leaving the small caves it seems likely that some were roosting in the cracks and crevices in the lava walls and ceiling. One bat, species unknown, was observed during the day deep in such a crack. Bat droppings were also present on the floor of the forest caves

The least common bats caught were Gould's Wattled Bat, Gould's Long-eared Bat, Large Forest Bat and Southern Forest Bat. This apparent difference in abundance may be an artefact of the trapping method or positioning of traps. Few Large Forest Bats were found, although that species was the dominant *Vespadelus* identified at Mt. Eccles NP in a survey conducted in April 1983 (*unpubl data*). The forearm length for that group was 35-36 mm. The bats captured at Mt. Eccles were Lesser Long-eared Bat (4), Gould's Long-eared Bat (1), Chocolate Wattled Bat (23), Large Forest Bat (4) and Little Forest Bat (1).

Common Bent-wing Bats *Miniopterus schreibersii* use the Byaduk Caves at infrequent intervals, but the major wintering or maternity caves appear to be Lake Gillear and Naracoorte Caves (Smith 1965). Bats were observed in the Byaduk Caves (Harman's, Fern and Church Cave) in Oct 1973 and similar numbers (perhaps a hundred or two) still occasionally roost in the latter two caves.

Table 5. Mammal species identified from surface bone deposits in lava caves in the forest (Sites 3 & 27) and the Byaduk Caves (Site 7)
Key: 1 = The Bridge (1973); 2 = Hill SW of Mt Napier (1977); 3 = Brown's Cave; A = jawbones of indeterminate age; B = limb fragments of indeterminate age; C = fresh skull of a young rabbit; D = fresh samples of regurgitated pellets from owl or kestrel contained jaw-bones of young Bush Rats and at least 100 jawbones of scincid lizards.

Species	1	2	3
Antechinus, Dusky *Antechinus swainsonii*	A		
Antechinus, Yellow-footed *Antechinus flavipes*	A/B	B	
Dog *Canis familiaris*	A		
Kangaroo *Macropus* spp	A		
Possum, Common Brushtail *Trichosurus vulpecula*	A		
Rabbit *Oryctolagus cuniculus*	C		
Rat, Broad-toothed *Mastocomys fuscus*	A	A	
Rat, Black *Rattus rattus*	A	A	
Rat, Bush *R. fuscipes*			D
Rat, Swamp *R. lutreolus*		B	

Table 6. Number and species of mammal observed by spotlight at night or during daylight hours within the Mt. Napier forest area
Key: Site = site no; No = no of surveys; Sp = spotlight; Dy = Day; A = Possum, Common Brushtail;
B = Kangaroo, Eastern Grey; C = Wallaby, Swamp ; D = Glider, Sugar ; E = Phascogale, Brush-tailed;
F = Echidna; G = Koala; H = Rabbit; I = Hare; J = Goat; K = Cat; L = Fox;
§ see Figure 1 for routes indicated - e.g. 6-18 indicates a section of Menzel's Pit Rd = Route 13-17-18 is a "circular" walk with one side following a fire track along part of the eastern boundary and the other mainly following Menzel's Pit Rd; * duration of survey (hours) indicated in brackets; # this column records the approximate number of visits made to the particular site for many purposes;
† observation in Jan 1987 by Laurie Kirkwood from North Byaduk of a small dark wallaby along track near site No. 6; + observed in Oct 1973 by Lionel Elmore.

Site§	No of Surveys Sp*	Dy#	A	B	C	D	E	F	G	H	I	J	K	L
4		4	-	-	-	-	-	-	1†	-	-	-	-	-
17-18	7(11.5)	30	52	-	-	-	1	1	-	21	-	-	3	-
13-17-18	1(3)	2	20	7	-	-	-	-	3	8	-	-	-	-
6-9	1(0.5)	10	1	-	-	-	-	-	-	-	-	-	-	-
17-26-9	1(2)	6	9	1	-	-	-	-	-	11	-	-	-	-
7	1(2)	20	-	-	-	-	-	-	-	10	-	-	6	1
13	2(3)	24	26	18	1	1	-	-	2	16	1	-	-	1
1-2-8	-	40	-	7	-	-	-	-	-	-	-	-	-	1
3	-	15	-	23	-	-	-	-	-	2	-	3	1	1
11	-	15	-	1	-	-	-	-	-	4	-	-	1	-
6-18	-	10	-	1	1†	-	-	-	-	-	-	-	-	-
6-27	-	2	-	3	1	-	-	-	2	1	-	6	-	1
TOTAL	13(22)	178	108	61	3	1	1	1	8	73	1	9	11	4

Table 7. Birds seen in the Mt. Napier forest (F), in the grassland margins (G), in temporarily flooded edges near Murroa Corner (W), or aerial nomads (A). # single observation. (A) nomadic flocks of thousands of White-browed Woodswallows and some Masked Woodswallows seen in and over the forest in October 1994; (E) Grey Butcherbird recorded by L.K.M. Elmore near Murroa corner in 1970.

Species	Location	Species	Location	Species	Location
Blackbird	F	Harrier, Swamp	G	Robin, Flame	G F
Black-cockatoo, Yellow-tailed	F	Heron, Pacific	W	Robin, Rose	F#
		Heron, White-faced	W	Robin, Scarlet	F
Boobook, Southern	F	Heron, Rufous Night	F#(E)	Rosella, Crimson	F
Brolga	G#	Hobby, Australian	F	Rosella, Eastern	F
Bronze-cuckoo, Horsfield's	F	Honeyeater, Brown-headed	F	Scrubwren, White-browed	F
Bronze-cuckoo, Shining	F	Honeyeater, New Holland	F	Shelduck, Australian	F W
Bronzewing, Common	F	Honeyeater, White-eared	F	Shrike-thrush, Grey	F
Butcherbird, Grey	F#(E)	Honeyeater, White-naped	F	Shrike-tit, Crested	F
Calamanthus, Striated	F	Honeyeater, White-plumed	F	Silvereye	F
Chat, White-fronted	G	Honeyeater, Yellow-faced	F	Sittella, Varied	F
Cockatoo, Sulphur-crested	F	Ibis Australian White	W	Skylark	G
Coot, Eurasian	W	Ibis, Straw-necked	W	Songlark, Brown	G
Corella, Long-billed	F	Jacky Winter	F	Sparrowhawk, Collared	F
Cormorant , Little Pied	W	Kestrel, Australian	G	Spoonbill, Yellow-billed	W
Cuckoo, Fan-tailed	F	Kingfisher, Sacred	F	Starling, Common	G
Cuckoo, Pallid	F	Kite, Black-shouldered	G	Swallow, Welcome	G F
Cuckoo-shrike, Black-faced	G F	Kite, Whistling	F#	Swan, Black	W
Currawong, Grey	F	Kookaburra, Laughing	F	Swift, Fork-tailed	A
Duck, Maned	F W	Lapwing, Masked	G	Swamphen, Purple	W
Duck, Musk	W	Lorikeet, Musk	F	Teal, Grey	W
Duck, Pacific Black	W	Lorikeet, Purple-crowned	F	Thornbill, Brown	F
Eagle, Little	F	Magpie, Australian	G F	Thornbill, Striated	F
Eagle, Wedge-tailed	F	Magpie-lark, Australian	G F	Thornbill, Yellow-rumped	GF
Fairy-wren, Superb	F	Martin, Fairy	G F	Thrush, Bassian (Ground)	F
Falcon, Black	G#	Martin, Tree	G F	Treecreeper, Brown	F
Falcon, Brown	G	Miner, Noisy	F#	Treecreeper, White-throated	F
Falcon, Peregrine	F	Needletail, White-throated	A	Triller, White-winged	F
Fantail, Grey	F	Owl, Barn	F	Wattlebird, Red	F
Firetail, Red-browed	F	Pardalote, Spotted	F	Weebill	F
Flycatcher, Restless	F	Pardalote, Striated	F	Whistler, Golden	F
Flycatcher, Satin	F#	Parrot, Blue-winged	F G	Whistler, Rufous	F
Frogmouth, Tawny	F	Parrot, Red-rumped	G	Willie Wagtail	F
Galah	F	Pipit, Richard's	G	Woodswallow, Dusky	F
Goldfinch, European	G	Quail, Brown	F	Woodswallow, Masked	F(A)
Goshawk, Brown	F	Quail, Stubble	F	Woodswallow, White-browed	F(A)
Goshawk, Grey	G#	Raven, Australian	G F		
Grebe, Hoary-headed	W	Raven, Little	G F		
Grebe, Australasian	W	Robin, Eastern Yellow	F		

Table 8. Body measurements of captured *Antechinus* and native *Rattus* species.
Key: A = Mass (g); B = Head-body (mm); C = Tail (%HB); D = Ear (mm); E = Pes (mm);
F = Fore claw (mm); G = Hind claw (mm); # value in brackets [ ] is the predicted change in the mean body measurement for a 10 g increase in body mass - see regression slope in Table 9.

Species				Body component s				
		A	B	C	D	E	F	G
Antechinus swainsonii								
Males	Mean#	55.1	109[6]	83[-1.9]	14.6[0]	19.3[0.3]	3.8[0.06]	2.9[0.07]
	SD	18.1	13.2	8.8	0.9	1.2	0.34	0.31
	Range	18-86	80-143	64-100	13-16	16-22	2.8-4.6	2-3.5
	N	37	37	37	35	36	37	37
Female	Mean	32.4	95[6]	85[-1.9]	14.0[0]	17.4[0.3]	3.6	2.6
	SD	9.2	10.5	8.3	1.1	1.1	0.34	0.40
	Range	12-45	72-110	70-100	13-16	15-19	3-4.1	2-3.3
	N	27	26	26	25	23	26	26
Antechinus stuartii								
Males	Mean	28	95[15]	98[-6.6]	16.4[0.8]	17.9[0.2]	2.0[0.14]	2.1[0.11]
	SD	4.4	9.4	5.4	1.3	1.3	0.22	0.25
	Range	21-35	80-110	91-106	15-19	16-20	1.7-2.5	2-2.7
	N	7	7	7	7	7	7	7
Female	Mean	18	81[15]	105[-6.6]	15.6[0.8]	15.8[0.2]	1.8[0.14]	1.9[0.11]
	SD	2.6	4.0	4.5	0.6	0.6	0.26	0.21
	Range	16-25	75-87	100-113	15-17	15-17	1.5-2.2	1.5-2.3
	N	12	12	12	12	12	12	12
Rattus fuscipes								
Males	Mean	93	145[3.2]	95[0]	20.0[0]	29.1[0.3]		
	SD	17.2	8.0	4.9	1.2	1.2		
	Range	58-130	125-159	87-108	18-23	27-31		
	N	28	24	24	24	24		
Female	Mean	80	141[3.2]	94[0]	20.2[0]	27.8[0.3]		
	SD	13.4	7.7	5.4	1.2	1.0		
	Range	55-100	126-154	77-102	18-22	26-29		
	N	27	26	26	24	25		
Rattus lutreolus								
Males	Mean	137	161[5]	70[0]	17.7[0]	30.2[0.7]		
	SD	16.7	9.5	6.8	1.2	0.8		
	Range	123-166	145-170	60-79	16-19	29-31		
	N	8	7	7	6	6		
Female	Mean	113	152.5	63[0]	18.9[0]	28.8[0.7]		
	SD	44.5	36.6	9.2	0.3	4.0		
	Range	30-154	100-180	56-76	18-19	22-32		
	N	6	4	4	4	5		

Elmore (*pers. comm.*) believed that cooking fires in at least four of the caves in the 1970s disrupted the bat population. I have not seen any bats in Harman's Cave in recent years; this is the most accessible cave and subject to the greatest disturbance from tourists. Visitor usage of Church Cave and Fern Cave is less intense and they have a higher ceiling. Large deposits of guano exist in Harman's, Bridge, Church and Fern Caves.

The predator scat analysis did not reveal species not found by live-trapping or observation. It was hoped that the presence of species such as the Southern Brown Bandicoot *Isoodon obesulus*, Feathertail Glider *Acrobates pygmaeus*, Eastern Pygmy Possum *Cercartetus nanus*, Common Ringtail Possum *Pseudocheirus peregrinus*, Fat-tailed Dunnart *Sminthopsis crassicaudata* and Yellow-footed Antechinus *Antechinus flavipes*) may have been revealed in this way.

Curiously, the scat analysis showed the presence of Brown Antechinus but not the Dusky Antechinus, which was trapped more regularly and frequently (64 *v.* 19 individuals). Since only 3 scats contained Bush Rat fur, but this species was also common in the forest (63 individuals), it is possible that this was due to the difficulty a fox would have in successfully hunting these species in their dense bracken habitat. In contrast, Brown Antechinus were trapped in more open habitat where a fox might operate more easily. Rabbits *Oryctolagus cuniculus* formed the major part of the fox diet and these, too, are usually seen on the more open areas and along tracks in the more dense areas. Rabbits are a major pest in this Park, although numbers recorded during the survey (Table 6) were not high.

Swamp Rats were trapped sporadically in

Table 9. Linear relationships (y = a + bx) between body mass (x) and various body measurements (y) of 4 native mammalian species from the Mt. Napier forest[#]

Key: A= Regression coefficients and statistics; B = Head-body (mm); C – Tail (%HB); D = Ear (mm); E = Pes (mm); F = Fore claw (mm); G – Hind claw (mm); r.s.d - residual standard deviation; r - correlation coeficient; * - regression is statistically significant; ns - regression is not statistically significant; # - data for males and females were combined, except where indicated, ‡ - intercept (a) differed significantly for males (17.4) v. females (16.3) ¶ - intercept (a) differed significantly for males (26.0) v. females (25.2); § - omitting animals less than 20 g

Species	A	B	C	D	E	F	G
Antechinus swainsonii							
	a	74	92	14.5	‡ ‡	3.4	2.4
	b	0.64	-0.19	0.00	0.034	0.006	0.007
	r.s.d.	7.1	7.9	0.88	1.04	0.35	0.34
	r²	0.75	0.17	0.00	0.51	0.11	0.14
	N	63	63	56§	59	63	63
	P < 0.05	*	*	ns§	*	*	*
Antechinus stuartii							
	a	54	117	14.2	12.5	1.6	1.8
	b	1.47	-0.66	0.077	0.19	0.014	0.011
	r.s.d.	3.3	4.2	0.9	0.8	0.27	0.24
	r²	0.88	0.48	0.22	0.69	0.09	0.07
	N	19	19	19	19	19	19
	P < 0.05	*	*	*	*	ns	ns
Rattus fuscipes							
	a	115	95	19.8	¶		
	b	0.32	0.009	0.004	0.033		
	r.s.d.	6.0	5.2	1.2	1.00		
	r²	0.44	0.001	0.003	0.41		
	N	50	50	48	49		
	P < 0.05	*	ns	ns	*		
Rattus lutreolus							
	a	91	65	20.6	20.8		
	b	0.52	0.02	-0.02	0.071		
	r.s.d.	11.6	8.6	1.1	1.0		
	r²	0.75	0.007	0.08	0.87		
	N	11	11	10	11		
	P < 0.05	*	ns	ns	*		

low numbers (14 individuals) but were not detected in the scat analysis. It is not uncommon in ungrazed, untrampled areas on farms in the region. The species is often regarded as a nuisance because of its habit of invading vegetable gardens and chewing the roots of young trees. At 'Lanark', near Branxholme, I concluded that the it was responsible for the loss of most of the Hickory Wattle *A. falciformis* planted in a woodlot. Other acacias, including Blackwood, did not appear to be affected, but suckering in this species could result from Swamp Rat activity.

The body measurements for captured *Antechinus* species indicated that animals of greater body mass had significantly shorter tails and ears, as a proportion of head-body length. This was not the case for the native *Rattus* species. For the Brown Antechinus, a large male (40 g) would have a tail length about 90% of head-body, compared with 98% for males of average mass (28 g). Published papers on *Antechinus* (*e.g.* Wakefield and Warneke 1963 and 1967) and field guides give mean

values which can be misleading as an aid to identification of specimens which are much smaller or larger than average.

The Yellow-footed Antechinus is usually much larger than the Brown Antechinus but large individuals of Brown Antechinus can sometimes be confused with the former. Since small individuals of Yellow-footed Antechinus probably also have proportionately shorter tails, as found here for Brown Antechinus and Dusky Antechinus, then one should be able to confidently differentiate between similar sized individuals of Yellow-footed Antechinus and Brown Antechinus on the basis of this character and the colour of fur on the feet and flanks.

The Broad-toothed Rat *Mastacomys fuscus* and the Yellow-footed Antechinus were not detected here by any survey method, but were identified from jawbones and other bones collected from lava caves at The Bridge (site 3) and from a lava cave on a small hill 0.7 km NW of site 6 (Table 5). The discoloured bones were collected from the soil surface but no attempt was made to determine an age for the material. These

species were also represented in sub-fossil bone deposits collected in the Byaduk Caves by Wakefield (1964). These species - and others recorded by Wake- field, including Eastern Pygmy Possum, Feathertail Glider, Fat-tailed Dunnart, Southern Brown Bandicoot, White-footed Dunnart *Sminthopsis leucopus*, Squirrel Glider *Petaurus norfolcensis*, Eastern Barred Bandicoot *Perameles gunnii* and Red-necked Wallaby *Macropus rufogriseus* - are present today in other areas of Victoria but apparently not now in the Mt. Napier State Park.

Animals were probably taken by predators into the Byaduk Caves from the surrounding plains of older basalt which, from the observations of Robinson in 1841 (see Presland 1977 and 1980), were 'thinly wooded and well grassed', with 'banksia' (Silver Banksia), 'eucalyptus' (Swamp gum and Manna Gum), 'lightwood' (Blackwood), 'cherry' (Cherry Ballart) and 'wattle' (Black Wattle). These species, with Sweet Bursaria and Drooping She-oak *Allocasuarina verticillata*, occur as remnants today. Drooping She-oak survives on Mt. Eccles but not in the Mt. Napier State Park. Robinson observed that Silver Banksia *Banksia marginata* was an abundant species on the basalt plains and Bruni (1903) observed that the country approaching the stony rises 'was originally covered with a dense growth of honeysuckles, of which scarcely one remains'. A remnant exists at Yatchaw, and in 1972 an old banksia log was found in the Bridge Cave (Lionel Elmore, pers. comm.). When that woodland disappeared, so too did the dependant animal species. The animals present in the sub-fossil record of the Byaduk Caves did not necessarily reside in the forest area of the newer volcanics.

The Fat-tailed Dunnart occurs nearby on the basalt plains. In June 1978 an individual was caught by a cat near Strathkellar and in 1983 I found a road-kill on the Mt. Napier Rd 10 km from Hamilton. These animals are occasionally found in freshly dug post holes or more often under posts left lying in the paddock. Three such instances have been reported to me since 1985, the most recent near Buckley Swamp in Sep 1996. Laurie Kirkwood (pers. comm.) recalls seeing this species about 40 years ago 'in the stones' on a farm just south of Mt. Napier.

Kirkwood also recalls at that time catching 'rat kangaroos' in rabbit traps. He described the animals as 'about 12 inches tall' and that they 'hopped like little kangaroos when released'. In 1975, the late Mrs Elmore saw an animal of this description when it crossed Coles Tk, about 500 m south of the stone fence (Lionel Elmore, pers. comm.). He had disturbed it while walking from the car into the bush. Presumably the animals were Long-nosed Potoroo *Potorous tridactylus*, a species recorded by Wakefield (1964) in bone deposits at Mt. Eccles, but apparently not now present there or at Mt. Napier. Frequent fires may have contributed to this loss. The baiting of rabbits with carrots impregnated with sodium fluoroacetate ('1080') may also have been a major cause because this species is more sensitive to 1080 than the Rabbit (McIlroy 1982).

Until recent years the Eastern Barred Bandicoot also occurred on the basalt plains near the park, although Kirkwood could not recall seeing the species in or near 'the stones'. The nearest occurrence of the Red-necked Wallaby, Southern Brown Bandicoot and Yellow-footed Antechinus is the Grampians (Gariwerd) National Park. I collected a road-kill of the Long-nosed Bandicoot near Mt. Abrupt in June 1975 and captured Yellow-footed Antechinus in the Dundas Range in June 1979. The nearest record of the Feathertailed Glider is the Wannon Falls Reserve, where a domestic cat captured an individual in June 1977 (Rob Rutter, *pers. comm.*).

A rare species that could frequent the park is the Tiger Quoll *Dasyurus maculatus*. It has been recorded in the Mt. Eccles and Heywood area (Emison *et al.* 1978, Menkhorst and Beardsell 1982) and it possibly also occurs at Mt. Napier. Reports by farmers of strange animals seen travelling over cleared land near the park appear from time to time, although not recently. Such reports include that of Alan Lewis of Gazette (Anon 1973a) and Brien Falkenberg of Byaduk (Anon 1973b). Some of the reported features suggest that the animals were Tiger Quolls, *viz.* large head in proportion to the body, massive lower jaw, rounded ears, excellent jumper, steady and relentless gait, tapered body, length 30 inches, height 18 inches

(Falkenberg): red-brown colour, large head in relation to the body, dog-like muzzle, long tail carried straight behind (Lewis). At about the time of these sightings Margaret Rundell also saw a Tiger Quoll on a farm at North Byaduk (Anon 1997); her photograph shows the spots on back and tail.

The absence of recent reported sightings of Tiger Quoll in the vicinity of Mt. Napier or Mt. Eccles, or elsewhere in the region, indicates that the species is either very rare or may no longer survive in the area. Its decline is associated with routine baiting of rabbits and foxes with 1080 poison, to which the Tiger Quoll is also susceptible (McIlroy 1981). McIlroy estimated that poison baits containing 3.22 g of 1080 (0.014 mg per g of meat) might cause 45% mortality in Tiger Quolls and 100% mortality in Dingoes. The current vermin control measures in both Parks need to be reassessed with regard to their impact on threatened carnivores such as the Tiger Quoll and the Brush-tailed Phascogale *Phascogale tapoatafa*. The latter species is probably highly at risk because other small dasyurids such as the Brown Antechinus and Dusky Antechinus are very susceptible, largely because of their small size (McIlroy 1981).

The most significant mammal found in the forest was that of a Brush-tailed Phascogale. One was seen on a cold night in May 1977 on Menzel's Pit Rd near the junction with Coles Track. It left the track and I followed, with the aid of a portable spotlight. By chance I noticed the animal head down in the fork of a tree that contained no hollows, some 5 m from the ground. After a minute or so it shuffled down the tree, head first and flattened against the smooth bark, until it was about 1.5 m from the ground. It backed up the vertical trunk a little way and then edged down again. I marvelled how it maintained its hold and later I could not discern on the bark any mark of its 5 mm needle-tipped claws. The animal then leaped to the ground and disappeared amongst the bracken and stone. It was presumably nesting in the hollow of a tree. At this time many of the largest old trees in the forest were found in this area (1 km from farmland) but were cut down in Jan 1981, following a fire. Ironically, the major damage to the forest was done by fire fighters who used the opportunity to conduct a training exercise.

A cat-killed Brush-tailed Phascogale from a farm at Buckley Swamp, near the Park, was given to Laurie Kirkwood (and seen by me) in Sep 1989. The species may be more common than indicated from surveys, but the population must be considered vulnerable.

Spotlight observations revealed many Common Brushtail Possums but no Common Ringtail Possums. The apparent absence of the latter species is surprising because it is not uncommon on the basaltic plains in the region. For example, it occurs at 'Lanark' (John and Cicely Fenton's property), at Laurie Kirkwood's farm at North Byaduk, and at Kelvin Rodgers property 5 km east of Hamilton. Fenton and Kirkwood have *Cupressus macrocarpa* hedges, exotic trees or dense native shrubberies. Rodgers has Swamp Gum with Thorn Wattle *A. paradoxa* and Sweet Bursaria.

Common Ringtail Possums will use hollows in branches or trunks where understorey species are unsuitable for their nests (Thomson and Owen 1963). I have observed this species using hollows in River Red Gums *E. camaldulensis* at the Dundas Ranges and there appears to be no shortage of similar nesting hollows in Manna Gums in the Mt. Napier forest. The absence of Common Ringtail Possums in the Mt. Napier forest indicates that the vegetation is not adequate as a food source.

While the Manna Gum forest would appear to suit the Koala *Phascolarctos cinereus*, and several introductions from Phillip Island have been made over the years, including 42 by the National Parks Service in 1981, the population has generally been very low. Severe fires may have contributed to this state, since Elmore (*pers. comm.*) observed that a colony south of the Mount was wiped out in the fire of Feb 1972. The current situation is quite healthy, since a 'koala count' by Friends of Eccles and Napier in Aug 1994 along a 7 km loop of tracks in the NE section of the park (Sites 13-17-18-13) revealed 12 adults and one juvenile.

The presence of Sugar Gliders *Petaurus breviceps*, or possibly of Feathertail Gliders, was indicated in Oct 1980 when a large quantity of dried gum leaves were found coiled in 2 nest boxes. There were

no leaves present when the boxes were inspected in Feb or April 1980. The nests were probably made during the winter because most of the leaves had faded to brown, although a few still had green pigment. No further activity was detected in April or July 1981 in five boxes which survived a fire in Dec 1980.

A Sugar Glider was observed on a moon-lit night in mid Oct 1994, in an area with tall Manna Gums, both dead and alive. Nearby were a few Black Wattles which are rare on the new volcanic soils. A half hour after sunset a glider landed with a thump near a small sap seep on a tree, some 5 m from the ground. The animal soon ascended to the treetop and glided away. The Yellow-bellied Glider *Petaurus australis* occurs in similar vegetation at Mt. Eccles National Park, along with Sugar Gliders, but neither it nor trees with bark gouged by the animals have been seen in the Mt. Napier forest. An injured juvenile from Mt. Eccles was cared for by Kay Aldridge at her Hamilton wildlife shelter in 1995-96.

Kangaroos once abounded in the area, as evident from a report (W.W. 1916) by the then 76 year old Mr Andrew Kerr of Pierrepoint, that in the early days '7,000 'roos were shot at Mt. Napier station in one winter ... every man had 7 or 8 'roo dogs ... 3 pence per head was obtained ... since the skins had come of value the poor 'roo had altogether disappeared'. At the unveiling of a monument at Mt. Napier in 1933 (Anon 1933) 'mementoes of the last kangaroo on Mt Napier Estate' were exhibited, 'The teeth and toes were later mounted in gold, inscribed and given to M. McGenniskin and R. Nagorcka'!

Whether or not that population of Eastern Grey Kangaroo *Macropus giganteus* was exterminated by the enthusiastic locals is uncertain. Rex Wedding (pers. comm.), an adjoining landowner, does not recall seeing any kangaroos or signs of them in the 1960s. They have retained a precarious presence in the area, perhaps through recolonisation from the Grampians (Gariwerd) NP or Mt. Eccles. They are capable of travelling long distances across farmland; sightings and night-time collisions with cars occur occasionally. The increase in numbers seen since 1986 may indicate that fewer are being shot since the land was declared a State Park.

The Swamp Wallaby *Wallabia bicolor* has been sighted occasionally in the forest (Bird 1992) and most recently in Feb 1995. That individual was seen briefly on a seldom-used forest track before it vanished into dense bracken. It is possible that this wary species has existed for many years here, unrecognised. However, the species may be a recent addition to the fauna because it was first reported for the Grampians in 1979 and is now common there and also occurs elsewhere in SW Victoria (Bird 1992). This species is susceptible to 1080 poisoning (McIlroy 1982) and the annual rabbit control program probably also limits the wallaby population in the targeted areas.

Cashmere Goats escaped from a farm adjacent to the park and have been prominent in the forest since the mid 1980s. They have denuded most of the prominent rocky areas in the forest and frequent a few of the Byaduk Caves. Ferns have virtually disappeared from the worst affected areas. Six goats were seen browsing in the open woodland; they gained access to the foliage of young Blackwoods by standing on their back legs and then bearing the sapling down between their front legs. Comprehensive action is required to eradicate this destructive pest.

The list of birds for the park (113 species, including 4 introduced species) is restricted by the lack of water and the lack of diversity in the flora. For example, the paucity of flowering species restricts the number of honeyeater species. There is no permanent surface water in the park and therefore no crakes, rails or waders. Eastern Grey Kangaroos and some birds use the permanent water of Murroa Pool near the NE edge which was formed by a tongue of lava blocking a small stream. Seventeen of the birds listed in Table 7 are found only on the narrow margins of the park, mostly during the late winter and spring when some of those areas are temporarily flooded. These species occur at other times on and near Murroa Pool and some, like the Maned Duck *Chenonetta jubata* and Australian Shelduck *Tadorna tadornoides*, were observed to nest at least 500 m inside the forest.

Significant bird records in the park include single sightings of Rose Robin *Petroica rosea* in Oct 1994, Satin Flycatcher

Myiagra cyanoleuca in Dec 1980. Black Falcon *Falco subniger* in March 1990 and Grey Goshawk *Falco hypoleucos* in Dec 1979. The Goshawk was seen on the ground eating a freshly killed rabbit at the Byaduk Caves. A pair of Peregrine Falcons *Falco peregrinus* hold a breeding territory in the area. Masked Woodswallows *Artamus personatus* and White-browed Woodswallows *A. superciliosus* were seen only on one occasion. The Woodswallows were in 3 flocks of several thousand birds, mostly White-browed Woodswallows, over a warm, still weekend in Oct 1994. The forest was alive with the tumult of their flight, colour and song. Birds seen on only a few occasions include Bassian Thrush *Zoothera lunulata*, Crested Shrike-tit *Falcunculus frontatus*, Eastern Yellow Robin *Eopsaltria georgiana*, Brown Treecreeper *Climacteris picumnus*, Barn Owl *Tyto alba*, Tawny Frogmouth *Podargus strigoides* and White-winged Triller *Lalage tricolor*. Blue-winged Parrots *Neophema chrysotoma* and Sacred Kingfishers *Todirhampus sancta* have been observed a little more frequently in the forest.

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Appendix

Body measurements and proportions for *Antechinus* and *Rattus* species at Mt. Napier State Park.

Body measurements for captured *Antechinus* and native *Rattus* species were made to characterise these local populations. These data are presented in Table 8. Age affects the size of the body and some body components and may alter the proportion of tail length to head-body length, although the extent of such effects are not given in field guides. Small animals are often caught but data is only available for "average" size animals of each species. Relationships between body mass and various body measurements are presented in Table 9, so that it is possible to deduce what effect a change in body mass has on a particular component.

The data were analysed by regression, with sex included as a variable in the linear regression model. A common line was fitted where there was no significant additional precision gained by fitting separate lines for each sex (different intercepts and slope, different intercept and same slope, or same intercept and different slope). In 2 instances, *pes* length for *A.swainsonii* and R. *fuscipes*, there was a significant difference between males and females in intercept but not slope.

For *A. stuartii* there were two instances, *pes* length and ear length, where an apparently significant effect of sex was ignored because inspection of the data showed that this was a result of a small range in the data for females, giving a contrary negative slope. In these instances the values for *pes* were 0.26 for males *v.* - 0.03 for females (r^2 0.63) and for ear length the values were 0.19 for males *v.* - 0.09 for females (r^2 0.43). In another case (ear length for *A. swainsonii*) it was apparent that if the 4 small animals (3 female) less than 20 g were not included in the set then there was no relationship between ear length and body mass. If these animals were included then the intercepts and regression slopes for males and females were 14.9 *v.* 12.0 and - 0.01 *v.* 0.06, respectively ($P < 0.05$, r^2 0.22).

While a curvilinear relationship between body mass and linear measurements might be expected, these were only significant ($P < 0.05$) in *A. swainsonii*, for which there was a wider range in body mass. A quadratic relationship, $y = a + bx + cx^2$, was significant for head-body, ear and *pes*. For these components, the coefficients a, b and c were 59. 1.32 and -0.0068; 11.1, 0.131 and - 0.00115; 14.5, 0.131 and -0.00079, respectively. Except for the very small animals, there was little advantage in using the quadratic equation.

For the native *Rattus* species there were no significant effect of change in body mass on tail length as a proportion of head-body length, or of ear length. However, these properties were significantly affected in the *Antechinus* species, particularly with Brown Antechinus *A. stuartii*. These calculations of regression slope (b) can be

used to enable comparisons to be made between animals of widely differing body mass. Looking at *A. stuartii* in Table 8, it may be deduced that the tail length as a proportion of head-body, is 6.6% less for animals that are 10 g heavier. The latter animals also have about 15 mm greater length of head-body. For animals differing by 21 g, the range found in the survey, the expected difference would be 14% and 31 mm, respectively. With Dusky Antechinus *A. swainsonii*, it is expected that one of the smallest animals caught (18 g) would have foreclaws 0.4 mm shorter than the largest caught (86 g), and that the tail length as a proportion of head-body would be 13% less.

The mean data here for *A. swainsonii* and *A. stuartii* may be compared with that of Wakefield and Warneke (1963 and 1967). For *A. swainsonii*, their data for head-body length and tail length (as % head-body) for preserved specimens of males *v.* females were 123 mm and 80% *v.* 116 mm and 77%, respectively. For *A. stuartii*, their data was 97 mm and 97% *v.* 91 mm and 92%, respectively. My data for tail length (as % head-body) for *A. swainsonii* and *A. stuartii* were 83% and 85% (males *v.* females) and 98% and 105% (males *v.* females), respectively. The agreement is surprisingly close, given the difficulties in measuring head-body length of live and very muscular *Antechinus*, the probability that the mean mass of Wakefield and Warneke's animals differed from those collected here, and the possibility of regional differences in such characters.

It may be difficult to differentiate in the field between large *A. stuartii* and small Yellow-footed Antechinus *A. flavipes* (not found in this survey), particularly because the pelage colour may appear rather similar. Wakefield and Warneke (1967) have shown that the latter species is usually a larger animal. My data indicates that a large Brown Antechinus male (40 g) would have a tail length some 90% of head-body length compared with 98% for males of average mass (28 g). Either value is rather larger than the mean value of 81% found by Wakefield and Warneke (1967) for the Yellow-footed Antechinus, or 82% that I measured for one individual of mass 42 g found dead on Eddie Coxon's farm at Nareen in 1979.

Since small individuals of Yellow-footed Antechinus probably also have proportionately shorter tails, as found here for Brown Antechinus and Dusky Antechinus, then one should be able to confidently differentiate between similar sized individuals of Yellow-footed Antechinus and Brown Antechinus on the basis of this character and the colour of fur on the feet and flanks.

Observations on the Ecology and Conservation of Yellow Eyebright *Euphrasia scabra* Scrophulariaceae, in Tasmania

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Abstract

The Yellow Eyebright *Euphrasia scabra* was widespread in northern and eastern Tasmania in the nineteenth century and the first half of the twentieth century. Today, only two populations are known, and both have declining numbers. This annual species tends to occur patchily and returns each year to approximately the same locations, which have a distinct species composition in contrast to the closely cropped herbfield and grassland that is its normal habitat. Recent apparent extinctions and the current decline in the numbers of the species may relate to increasing shrub cover. Reservation, fire management and *ex situ* cultivation, including reintroductions, may be necessary to maintain the species in Tasmania. (*The Victorian Naturalist* **114**, 1997, 67-73).

Introduction

The Yellow Eyebright *Euphrasia scabra* (Fig 1), is a semiparasitic annual herb in the Scrophulariaceae family. It once occurred widely throughout south-eastern and south-western Australia. Last century it was described as flourishing throughout extratropical Australia (Mueller 1865). It typically occurs in short herbfields or grasslands with low shrub or tree cover (Thompson 1992), but is also recorded from dry heath and forest, sand dunes and salt lakes (Barker 1984). *E. scabra* is one of only seven annual species in a genus of approximately 47 taxa in Australia, an adaptation thought to relate to shortened growth seasons in the habitat where these annuals occur (Barker 1982).

The species has suffered a major decline in its range since European settlement. For example, in Victoria the species survives in only seven of the twenty-nine localities from which it has been collected (Thompson 1992). Briggs and Leigh (1988) classified it as 'vulnerable to extinction' at a national level. In Victoria and Tasmania, where the only recently verified populations exist, the species has since been classified as 'endangered' at a state level (Gullan *et al.* 1990; Kirkpatrick *et al.* 1991). *E. scabra* has been the subject of an Action Statement under the Victorian Flora and Fauna Guarantee Act (Thompson 1992).

In this paper we report the results of our

investigations in Tasmania into the past and present distribution, recent population changes and the ecology of *E. scabra* from a plant community context. We also discuss its conservation needs.

Methods

The distribution of *E. scabra* in Tasmania was determined using herbarium collections from the Herbarium of the Tasmanian Museum and Art Gallery and the National Herbaria of New South Wales and Victoria, literature references and field survey data. All sites from which the species was recorded were visited during the flowering season, which varied from early October to March-April. Searches were also made for the species in environments similar to those from which it had previously been recorded.

All higher plant species were recorded from 1 x 10 m quadrats in vegetation with *E. scabra*. These data were manually manipulated to produce a sorted table. The sorted table allows clarification of the relationships between plant communities or sites, and of the qualitative differences between plots. Altitude (to the nearest 20 m), surface geology and soil characteristics including pH, texture and colour of the A horizon were noted or measured in the field. The slope and aspect of each site were determined using a clinometer and compass respectively.

Floristic and abundance data were collected for fourteen quadrats measuring 40x40 cm which were arranged 0.5 m apart in a transect at Dukes Marsh. The percent cover of all vascular plant species

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Fig. 1. Yellow Eyebright *Euphrasia scabra*. Drawing by Richard Hall.

within each quadrat was recorded to give the relative abundance of each species. This was recorded using a modified Braun-Blanquet Cover Abundance Scale (Mueller-Dombois and Ellenberg 1974) on a scale divided into six levels (i.e. 1 = <1%, 2 = 1-5%, 3 = 5-25%, 4 = 25-50%, 5 = 50-75% and 6 = 75-100%). The abundance data for the fourteen quadrats was ordinated (arranged on the basis of similarity) using one-dimensional non-metric multidimensional scaling using the default options of the computer program DECODA (Minchin 1990), a database for storing ecological data. The ordination scores were used to order the quadrats and the species were sorted by eye. Species nomenclature follows Buchanan (1995).

The fourteen quadrats and 63 others of the same size, also arranged in a transect with 0.5 m between quadrats, were used for an annual summer count of the numbers of *E. scabra* individuals between 1990 and 1994.

Euphrasia scabra seed from Dukes Marsh was collected in February, 1992 and stored at 20° C for 10 months. In October, 1992 *E. scabra* seed was placed on a sand:vermiculite:loam mix in nine germination trays measuring 28 x 12 cm, and was stratified for four weeks at 2° C. The seed was covered in a fine layer of sterilized sand. The species is semi-parasitic (Barker 1982), so the seed was sown with seed of Kangaroo Grass (*Themeda triandra*). The germination trays were then transferred to a glasshouse in Hobart with no artificial heating or lighting. In early spring the trays were transplanted into three prepared sites. The three sites were within 0.5 km of each other at the Waterworks Reserve, Hobart, a past locality for the species. All vegetation was removed and the clay-loam soils loosened and dug to a depth of 10 cm, and three trays, each containing hundreds of individuals, were planted at each of the three localities. The sites were located on a

creekline in open grassy vegetation on the edge of open forest, on a drainage line with no extant vegetation in White Peppermint (*Eucalyptus pulchella*) woodland, and on a drier site in *E. pulchella* woodland. The transplants were watered at regular intervals throughout the spring and summer following their transplantation. The planting sites were monitored for several years.

Results
Past and present distribution

Herbarium specimens suggest that *E. scabra* had a wide natural range in Tasmania (Fig. 2). The species was collected by Brown at Lagoon Beach and Port Dalrymple in 1804, and by Milligan in 1842 in the north-west of the state in a valley near Rocky Cape. Other nineteenth century herbarium records were from Harefield near St. Marys (1879), from Mount Arthur at 3600 feet (1886), from near Launceston (1887) and from Mt. Nelson (1899). Between 1900 and 1950 there were herbarium records from Mt. Nelson, Waterworks, Proctors Road, St. Marys, George Town and Port Sorrel. Rodway (1903) stated that the species was found on the north coast, at Georges Bay,

on dry hills near Hobart, at Cressy, and near Hamilton. He thought that it was probably common in many parts but was overlooked. Since 1950 the species has been collected from Hockeys Marsh, Dukes Marsh, Black Marsh, Tumbledown Creek and Mt. Nelson. Today, the species can only be found in Tasmania at Dukes Marsh and Black Marsh, two localities which are <3 km apart and are both within the St. Paul River catchment. At the latter locality, where it was once abundant, only one individual could be located in the summer of 1996.

Floristic Patterns

The five quadrats form a continuum from wet grasslands with high species richness (i.e. >25 species per m²) characterized by species such as Swamp Pennywort *Centella cordifolia*, Wallaby Grasses *Danthonia laevis* and *D. penicillata*, Thread Rapier-sedge *Lepidosperma filiforme*, and Swamp Daisy Bush *Olearia glandulosa*, to less grassy vegetation richer in heaths and graminoids, and characterized by such species as Spreading Rope-rush *Empodisma minus*, Mountain Heath Myrtle *Baeckea gunniana* and Woolly Tea-tree *Leptospermum lanigerum*. The species most frequently occurring with *E. scabra* are Wiry Bushpea *Almaleea subumbellata*, Tasmanian Bottlebrush *Callistemon viridiflorus*, Alpine Cotula *Cotula alpina*, St. Johns Wort *Hypericum japonicum* and Flat Cord-rush *Restio australis* (Table 1). Exotic species are relatively uncommon. The three quadrats which were less grass-rich had no exotics out of 33, 21 and 45 species. The two most grass-rich quadrats had 1 and 4 exotic species out of 35 and 37 species respectively.

All the sites on which the species survived are between 500-1000 m above sea level, but many of the earlier records are from sites at much lower altitude. The range of vegetation types in which the species occurs has undoubtedly contracted.

Population change at Dukes Marsh

The total density of *E. scabra* in the quadrats at Dukes Marsh steadily declined between 1990 and 1994 (1990-40; 1991-37; 1992-16; 1993-15; 1994-7). Nineteen of the 77 quadrats had no individuals of the species during the observation period.
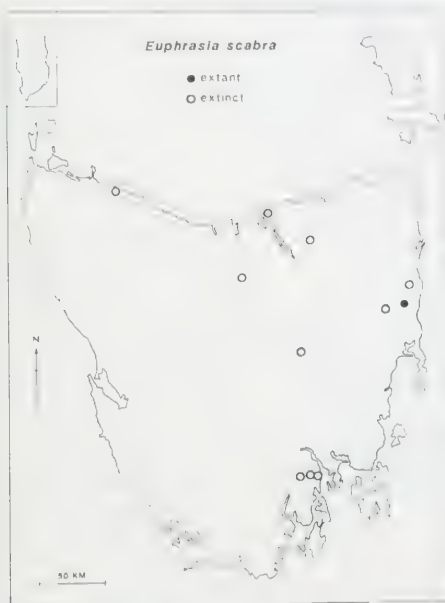

Fig. 2. The past and present distribution of *Euphrasia scabra* in Tasmania. The extant population represents two localities (Dukes Marsh and Black Marsh) which are <3 km apart.

Table 1. Sorted table for quadrats with *Euphrasia scabra*.
Key: A = 788, Dukes Marsh; B = 1013, Dukes Marsh; C = 1017, Black Marsh; D = 1087, Mountain Creek; E = 5, Tumbledown Creek (the Data for Black and Tumbledown Creeks was kindly made available by A. Moscal); * = introduced species.
Table 1 data was manually manipulated to produce a sorted table to allow clarification of the relationships between plant communities or sites and of the quantitative differences between plots. (see . under 'Methods', para 2, and under 'Floristic Patterns'.

SPECIES	A	B	C	D	E	SPECIES	A	B	C	D	E
Acaena novae-zelandiae	1	1	-	-	-	*Hypochoeris radicata	-	1	-	-	-
Danthonia laevis	1	1	-	-	-	Agrostis parviflora	-	1	-	-	-
Danthonia nivicola	1	1	-	-	-	Asperula spp.	-	1	-	-	-
Gonocarpos micranthus	1	1	-	-	-	Carex breviculmis	-	1	-	-	-
*Leontodon taraxacoides	1	1	-	-	-	Geranium solanderi	-	1	-	-	-
Lepidosperma filiforme	1	1	-	-	-	Hakea microcarpa	-	1	-	-	-
Lomandra longifolia	1	1	-	-	-	Bracteantha subundulata	-	1	-	-	-
Olearia glandulosa	1	1	-	-	-	*Holcus lanatus	-	1	-	-	-
Oxalis perennans	1	1	-	-	-	Hydrocotyle sibthorpioides	-	1	-	-	-
Veronica gracilis	1	1	-	-	-	Leptospermum scoparium	-	1	-	-	-
Centella cordifolia	1	1	1	-	-	Oreomyrrhis eriopoda	-	1	-	-	-
Melaleuca squamea	1	-	1	-	-	Schoenus apogon	-	1	-	-	-
Microtis spp.	1	-	1	-	-	Spiranthes australis	-	1	-	-	-
Gahnia graminifolia	1	-	1	-	-	*Trifolium dubium	-	1	-	-	-
Banksia marginata	1	-	1	-	-	Olearia myrsinoides	-	-	1	-	-
Euchiton traversii	-	1	1	-	-	Leptorhynchos squamatus	-	-	1	-	-
Gonocarpus serpyllifolius	-	1	1	-	-	Leptocarpus tenax	-	-	1	-	-
Hydrocotyle hirta	-	1	1	-	-	Lomatia tinctoria	-	-	1	-	-
Almaleea subumbellata	1	1	1	-	1	Arthropodium milleflorum	-	-	1	-	-
Callistemon viridiflorus	1	1	-	1	1	Bauera rubioides	-	-	1	-	-
Cotula alpina	1	1	-	1	1	Bedfordia linearis	-	-	1	-	-
Hypericum japonicum	1	1	-	1	1	Bossiaea prostrata	-	-	1	-	-
Restio australis	1	1	-	1	1	Brachyscome spathulata	-	-	1	-	-
Euphrasia scabra	1	1	1	1	1	Chrysocephalum apiculatum	-	-	1	-	-
Carex gaudichaudiana	1	-	-	-	1	Hibbertia riparia	-	-	1	-	-
Gnaphalium collinum	1	-	1	1	1	Craspedia glauca	-	-	1	-	-
Poa labillardierei	1	-	-	1	1	Danthonia penicillata	-	-	1	-	-
Ozothamnus hookeri	1	-	-	1	1	Drosera binata	-	-	1	-	-
Epacris gunnii	-	1	-	-	1	Epacris lanuginosa	-	-	1	-	-
Pentapogon quadrifidus	-	1	-	-	1	Eriochilus cucullatus	-	-	1	-	-
Poa gunnii	-	1	-	1	1	Eucalyptus pauciflora	-	-	1	-	-
Eucalyptus rodwayi	-	-	1	1	1	Stipa aphylla	-	-	1	-	-
Hakea lissosperma	-	-	1	1	1	Viola hederacea	-	-	1	-	-
Leptospermum lanigerum	-	-	1	1	1	Orites diversifolia	-	-	-	1	-
Baeckea gunniana	-	-	-	1	1	Drosera pygmaea	-	-	-	-	1
Bossiaea riparia	-	-	-	1	1	Agrostis avenacea	-	-	-	-	1
Carpha alpina	-	-	-	1	1	Eucalyptus gunnii	-	-	-	-	1
Empodisma minus	-	-	-	1	1	Gratiola nana	-	-	-	-	1
Eucalyptus delegatensis	-	-	-	1	1	Hakea epiglottis	-	-	-	-	1
Eucalyptus dalrympleana	-	-	-	1	1	Ozothamnus rosmarinifolius	-	-	-	-	1
Gentianella diemensis	-	-	-	1	1	Isolepis crassiuscula	-	-	-	-	1
Juncus pallidus	-	-	-	1	1	Isolepis fluitans	-	-	-	-	1
Rubus gunnianus	-	-	-	1	1	Juncus bufonius	-	-	-	-	1
Bossiaea cordigera	1	-	-	-	-	Juncus falcatus	-	-	-	-	1
Epilobium spp.	1	-	-	-	-	Juncus sandwithii	-	-	-	-	1
Wurmbea dioica	1	-	-	-	-	Luzula poimena	-	-	-	-	1
Hypoxis hygrometrica	1	-	-	-	-	Myriophyllum pedunculatum	-	-	-	-	1
Phyllanthus australis	1	-	-	-	-	Nymphoides exigua	-	-	-	-	1
Plantago glabrata	1	-	-	-	-	Oreobolus distichus	-	-	-	-	1
Poa rodwayi	1	-	-	-	-	Plantago paradoxa	-	-	-	-	1
Poranthera microphylla	1	-	-	-	-	Ranunculus decurvus	-	-	-	-	1
Ranunculus pimpinellifolius	1	-	-	-	-	Ranunculus glabrifolius	-	-	-	-	1
Uncinia spp.	1	-	-	-	-	Thelymitra venosa	-	-	-	-	1
						Utricularia dichotoma	-	-	-	-	1

eight had no individuals in four of the observation periods, 16 had no individuals in three of the observation periods, nine had no individuals in two of the observation periods, 14 had no individuals in one of the observation periods and 11 had individuals in all observation periods. In 29 of the quadrats *E. scabra* appeared after at least an absence of a year. In 25 of these cases *E. scabra* was present in a quadrat less than one metre away in the previous year. The spatial pattern of distribution of *E. scabra* on the transect lines did not vary greatly between years, but there was a decline in absolute numbers (Fig. 3). The large peaks recorded in 1990 were represented by smaller peaks of *E. scabra* in the same areas on the transect line in later years. Individuals were always within close proximity to individuals recorded in previous years (i.e. within a radius of 5 cm).

There was a strong relationship between species composition and the occurrence and density of *E. scabra* in the transect at Dukes Marsh (Table 2). The quadrats with shrub species, in this case Wiry Bushpea *Almaleea subumbellata* and Gunns Coral Heath *Epacris gunnii*, either lacked *E. scabra* or contained it in low densities (Table 2). *E. scabra* was less frequent in the group of quadrats characterized by the wetland plant Swamp Pennywort *Centella cordifolia*, than in those characterized by a group of herbs and grasses of better-drained ground, such as Buzzy *Acaena novae-zelandiae* and Shining Pennywort *Hydrocotyle sibthorpioides*.

Reintroduction

At all three sites the planted individuals flowered, set and released seed. The following summer there were a few individuals of *E. scabra* at one of the re-establishment sites. There have been none since. The site where some *E. scabra* established in the second year was in a drainage line where there was no competition from other species. The creekline site was heavily invaded by exotic grasses such as Yorkshire Fog Grass *Holcus lanatus* and Cocksfoot *Dactylis glomeratum*. At the third site, which was much drier than the other two sites, most of the Kangaroo Grass *T. triandra* also died despite watering, but the site was only slowly re-invaded by other species.
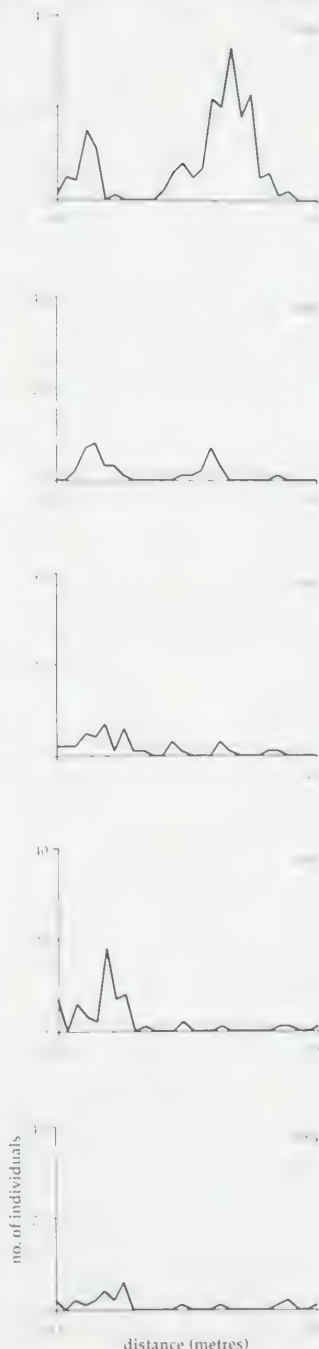
Fig. 3. Variations in the numbers of *Euphrasia scabra* individuals in 40 x 40 cm quadrats 0.5 m apart on a transect line at Dukes Marsh, 1990-1994.

Table 2. Percent cover of vascular plant species and density of *Euphrasia scabra* in 40 x 40 cm permanent quadrats at Dukes Marsh. 1 = 1%, 2 = 2-5%, 3 = 6-25%, 4 = 26-50%, 5 = 51-75%, 6 = 76-100%. Percentage cover was recorded using a modified Braun-Blanquet Cover Abundance Scale and the data arranged on the basis of similarity between quadrats, using a computer programme (see under Methods and Results, Population change at Dukes Marsh).

Species	2	3	11	12	10	13	1	8	7	9	14	4	5	6
Euphrasia scabra 1990	-	2	5	-	2	-	3	3	-	2	-	4	3	-
Euphrasia scabra 1991	2	1	3	4	6	4	3	-	-	4	-	3	3	-
Euphrasia scabra 1992	2	3	3	3	4	3	2	1	-	2	-	-	-	-
Euphrasia scabra 1993	2	2	-	2	4	2	3	-	-	-	-	-	1	-
Euphrasia scabra 1994	3	1	-	-	1	2	-	-	-	-	-	2	1	-
Veronica gracilis	1	1	1	-	-	-	-	-	-	-	-	-	2	-
Cotula alpina	-	1	-	1	-	-	-	-	-	-	-	-	-	-
Helichrysum scorpioides	-	1	2	-	1	-	-	-	-	-	-	-	-	-
Ranunculus decurvus	1	-	1	3	1	1	-	-	-	-	-	-	-	-
Holcus lanatus	1	1	1	2	3	2	3	2	-	-	-	-	-	-
Hydrocotyle sibthorpioides	2	2	3	1	1	1	1	1	-	1	-	-	-	-
Gonocarpus micranthus	2	2	-	1	-	-	1	-	-	1	-	-	-	-
Acaena novae-zelandiae	1	-	1	2	5	-	2	-	-	3	-	-	-	-
Oxalis perennans	-	-	-	1	1	1	-	1	1	-	-	-	-	-
Prunella vulgaris	-	-	-	-	1	1	1	1	-	-	-	1	-	-
Juncus spp.	1	-	2	2	2	3	3	2	2	-	-	3	-	2
Euchiton traversii	1	1	1	-	-	1	-	-	1	2	1	1	-	-
Carex breviculmis	3	3	2	2	-	1	1	-	2	1	2	2	1	-
Hypericum japonicum	2	1	1	1	1	1	1	2	1	1	2	-	1	-
Leontodon taraxacoides	2	1	1	3	2	2	3	2	1	2	1	1	1	2
Gonocarpus serpyllifolius	4	3	3	1	-	3	3	1	4	4	-	3	2	2
Plantago varia	-	-	2	4	2	3	2	2	1	2	1	3	-	1
Centella cordifolia	-	1	-	-	1	-	1	1	2	1	2	1	2	1
Poa gunnii	-	-	1	-	1	-	2	-	-	3	3	2	3	6
Danthonia spp.	-	-	3	3	2	5	4	4	3	4	2	5	3	-
Hypochoeris radicata	-	-	-	1	-	1	1	-	1	-	-	2	-	1
Agrostis parviflora	-	-	-	-	1	1	1	1	1	2	2	2	-	-
Almaleea subumbellata	-	-	-	-	-	-	-	1	1	-	-	1	-	-
Ehrharta stipoides	-	-	-	-	-	-	-	1	-	1	-	-	3	-
Mazus pumilio	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Erigeron pappachroma	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Schoenus apogon	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Carex gaudichaudiana	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Empodisma minus	-	-	-	-	-	-	-	4	-	-	-	-	-	-
Epacris gunnii	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Lyperanthus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Discussion

The causes of the disappearance of *E. scabra* from lowland sites in Tasmania are unknown. All the lowland sites from which it was recorded in Tasmania are in areas of considerable agricultural and urban development. However, especially in the Waterworks/Mt. Nelson area in Hobart, there are many apparently suitable sites remaining in at least a predominantly natural condition. It may be that introduced plants or invertebrates are the cause or causes of local extinction. An alternative hypothesis is that populations were lost through changes in disturbance regimes.

The decline and local extinction of the species is not confined to lowland sites in developed areas. The Tumbledown Creek and Hockeys Marsh populations have disappeared in the last five years. At both sites there has been substantial shrub invasion. The Black Marsh population has almost disappeared in the last five years. Again, the shrub layer has expanded over the grassy sward in the absence of fire. In Dukes Marsh there is evidence of decline, although separating the impacts of the summer/early autumn droughts of the last half decade from potential causes related to vegetation dynamics is difficult. At Dukes

Marsh there is evidence of a negative association between *E. scabra* and shrubs.

It may be that the survival of *E. scabra* in Tasmania depends on frequent enough fires to repel the shrub and tall graminoid invasion of the herbaceous sward that is kept short by wombat and wallaby grazing. Yet, annuals are frequently susceptible to local extinction if fire kills them between germination and seed release. There is some intimation that *E. scabra* can survive in the soil seed store. A single individual germinated from soil from a semi-natural grassland at Ross, where the species has not been noted in the well-studied present vegetation (Gilfedder and Kirkpatrick 1993). Fuel reduction burns at Hockeys Marsh and Black Marsh are scheduled for autumn 1996 to determine whether *E. scabra* will return from the soil seed store once shading is removed. The phenology of the species in Tasmania suggests that if any areas are to be burned where the species survives, late autumn burns would be the most appropriate since seed will have time to set and disperse under this regiime.

The results of this research give no further indications as to the reasons for the disappearance of the species in Tasmania, particularly at the sites from which it has become locally extinct in the last decade. Shrub and graminoid invasion is implicated in the decline of the species at some of the localities where there has not been fire in the recent past to maintain an open grassy sward. However, at Dukes Marsh, where no invasion of shrubs and graminoids has occurred there has been a steady decline in the number of individuals of *E. scabra*, although it has now appeared in places at the Dukes Marsh site where it was previously unrecorded. There is a strong case for *ex situ* measures to conserve the Tasmanian genotypes of the species. It is relatively easily maintained in captivity, and persistence with reintroduction efforts, perhaps into recently burned moist sites in the Waterworks/Mt. Nelson area, may meet with greater rewards than our attempt.

Dukes Marsh, which is presently State Forest, is an extremely important site for the conservation of threatened plants, and also contains a population of the nationally vulnerable Tasmanian endemic shrub, *Acacia axillaris* (Lynch 1993). It deserves secure reservation status. The one small population, apparently reduced to one individual at Black Marsh in the Douglas-Apsley National Park, needs urgent experimentation with shrub reduction if the species is to be maintained, and is scheduled for burning in autumn, 1996 (A. Pyrke *pers. comm.*).

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Host Plant Use and Ant Interactions of the Victorian Hairstreak *Pseudalmenus chlorinda zephyrus* Blachard, a Myrmecophilous Lycaenid Butterfly

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Abstract

This paper describes the abundance of the juvenile stages of the myrmecophilous Victorian Hairstreak butterfly *Pseudalmenus chlorinda zephyrus* over two years at a site in Sherbrooke Forest. The butterfly has an obligate association with the ant *Anonychomyrma* sp. near *foetans*, and although ants are sometimes found on plants without butterfly larvae, the latter are never found on plants without their tending ants. Larger larvae attract more ants, and the smaller, relatively untended larvae behave more cryptically. The larvae were found on *Acacia melanoxylon* and *A. dealbata*, but not in similar numbers over the two years. The larvae showed no preference for trees of a particular height, but *A. melanoxylon* plants with larvae tended to have more bipinnate leaves than plants without larvae. The Sherbrooke Forest population is unusual because it includes relatively large numbers of plants infested with larvae, while other populations, in contrast, may comprise only a few larvae on a single plant. (*The Victorian Naturalist*, **114**, 1997,74-76).

Introduction

Many species of the butterfly family Lycaenidae associate with ants and, in most cases, the association is regarded as mutualistic (e.g. Pierce 1987, 1989). The lycaenid larvae provide the ants with nutritious secretions from specialised glands and, in return, the ants protect the larvae from parasitoids and predators (e.g. Pierce et al. 1987). The larval and pupal association with their tending ants has profound effects on the behaviour of the adult butterflies. For example, ovipositing female Imperial Blue *Jalmenus evagoras* prefer to lay eggs on host plants with workers of the tending ant *Iridomyrmex* sp. 25 (ANIC) *anceps* group, than on host plants without these ants (e.g. Pierce and Elgar 1985; see also Atsatt 1981). More generally, the host-plants of myrmecophilous lycaenids are more likely to include species that are rich in nitrogen, perhaps because of the additional nutrients required to feed the tending ants (Pierce 1985). Male *J. evagoras* also use ants as cues to locate pupae that are about to eclose, and sometimes a single pupae may attract a spectacular 'mating-ball' of attending males (Elgar and Pierce 1988).

The Australian Hairstreak *Pseudalmenus chlorinda* Blachard (Lycaenidae) is the only species of this endemic Australian genus belonging to the sub-family Theclinae, and is only found in south-eastern Australia and Tasmania. There is little size dimorphism between the sexes, both measuring around 25 mm in length. Adult males are brown-black above with two orange spots on the

forewing, which are darker and more extensive in the female. The hindwing usually has a central orange spot, red subterminal band and a short black tail. The underside of the wing is light grey; the forewing has two or three black bands and the hindwing has one or two bands of black spots and a red subterminal band. The larvae are pale green, and the older instars have two pink and grey lateral bands. Further descriptions of the butterfly, including illustrations, are given in Common and Waterhouse (1981) and Fisher (1995).

There are thought to be seven subspecies (Common and Waterhouse 1981) and perhaps eight (Prince 1993), of which only the Victorian Hairstreak *P. c. zephyrus* (Waterhouse and Lyell, 1914) is not listed as 'Threatened' (New 1991; Prince 1993). *P. chlorinda* is widespread but very localised and, characteristically, populations comprise only a few individuals (New 1993). Females oviposit around November on young stems of *Acacia melanoxylon* or *A. dealbata*. The larvae aggregate and feed in the open on their *A. melanoxylon* food plants. Pupation occurs between December and January. The pupae are found under stones, or under the bark, crevices or holes of mature host plants or nearby eucalypts where the ants are also found (Common and Waterhouse 1981). The individuals overwinter as pupae, and the adults emerge from the pupal case the following August to December.

Like other lycaenid butterflies, the larvae and pupae of *P. chlorinda* are tended by

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numerous ants *Anonychomyrma* sp. near *foetans*. The tending ant, *A.* near *foetans* establishes large colonies in the hollow trunks of eucalypts, and the many thousands of workers may forage over large distances. Interestingly, the distribution of some other invertebrates are also closely associated with this species of ant (e.g. Cole *et al.* 1994). The association between *P. chlorinda* and their tending ants is thought to be obligate, but reports are largely anecdotal (e.g. Common and Waterhouse 1981; Prince 1993; New 1991). Here, we report on the influence ants and host plants have on the distribution of the juvenile stages of the Victorian Hairstreak, and describe some aspects of the behaviour of ants tending the larvae.

Methods

The Victorian Hairstreak *P. c. zephyrus* was observed at Sherbrooke Forest, approximately 30 km east of Melbourne. A perimeter fence, which had been erected previously by sections of the community to reduce disturbance by human visitors, encloses an area of around 1200 m². The vegetation within the enclosure includes Blackwood *Acacia melanoxylon*, Silver Wattle *A. dealbata*, Black Wattle *A. decurrens* and Mountain Ash *Eucalyptus regnans*. Other plants include Blanket Leaf *Bedfordia arborescens*, Hazel Pomaderris *Pomaderris aspera*, Dogwood *Cassinia aculeata*, Hard Tree Fern *Cyathea australis* and Tree Daisy *Olearia* spp.

We conducted surveys during late December and early January in both 1994/5 and 1995/6. Every Blackwood within the enclosure was individually identified and we made the following measurements: the height of the tree; the foliage composition (determined by counting the number of leaves and phyllodes on each tree or, for larger trees, making an estimate based on counts of several branches); the number, size and location of Hairstreak larvae and eggs; and the number and behaviour of the ants, *Anonychomyrma* sp. near *foetans*.

Results and discussion

In the summer of 1995/1996, *P. c. zephyrus* were found on 11 of the 37 *A. melanoxylon* plants located within the enclosure, and four of these plants were infested in the following year. A single larva was found on only one *A. dealbata* plant in 1995/6, but five of the 15 plants were infested in the following

year. The mean height of *A. melanoxylon* plants in the enclosure in the first year was 1.77 m (SE = 0.14, n = 37), and the height of plants with larvae (mean = 2.05, SE = 0.34) was not significantly different from that of trees without larvae (mean = 1.65, SE = 0.12; t = 1.36, df = 35, NS). Although there was no significant difference in the number of phyllodes on *A. melanoxylon* plants with and without larvae, the number of juvenile bipinnate leaves tended to be greater on *A. melanoxylon* plants with larvae (mean = 5.2, SE = 0.5, n = 11) than on plants without larvae (mean = 4.5, SE = 0.2, n = 26; t = 1.74, p = 0.09). Perhaps the bipinnate leaves contain a higher nitrogen content (see Pierce 1985), although it is also possible that bipinnate leaves are produced in response to increased herbivore damage.

The mean number of larvae per plant for the two host plants are given in Table 1. The Sherbrooke Forest population of *P. c. zephyrus* is unusual because it supports relatively large numbers of plants with larvae and relatively large numbers of larvae per tree. Populations of this species elsewhere in Australia are characteristically small, perhaps confined to a single tree in small patches of habitat (New 1991; Prince 1993; N. E. Pierce, *pers. comm.*).

Pseudalmenus chlorinda zephyrus appears to be obligately associated with ants; in both years, larvae were never found on trees without ants (n = 21 trees) and larvae were present on 11 of the 16 trees with ants (c2 = 25.2, P < 0.001). Furthermore, individual larvae were only very rarely found without any attending ants; the mean number of ants per larvae was 3.8 (SE = 0.2, n = 74 observations, which include no more than two observations per individual) and larger larvae had significantly more attending ants than smaller larvae (Fig. 1). It is possible that the larger larvae can secrete more of the

Table 1. The mean number of *P. c. zephyrus* larvae per plant for two host plant species in two years at Sherbrooke Forest. Standard errors are given in parentheses, and n refers to the number of infested plants.

Host plant	Larvae per host plant	
	1994-1995	1995-1996
A. melanoxylon	2.5 (0.5) n = 11	3.2 (1.9) n = 5
A. dealbata	1 n = 1	6.2 (1.9) n = 5

nutritious material and hence attract more ants. First instar larvae attracted few tending ants and therefore received relatively little protection. Indeed, five first instar larvae disappeared from one tree shortly after the only other larva on the tree pupated and the ants ceased to visit the tree. The lack of ant protection may be reflected by the cryptic colouring of the first instar larvae, and their preference to reside in sheltered positions along the stem rather than the leaves.

The larvae of *P. c. zephyrus* tend to aggregate irrespective of their position on the plant. The number of larvae in an aggregation varied, but could be as many as 10. The mean size of larvae in aggregations (16.0 mm, SE = 0.85, n = 45 observations) was not significantly different from that of solitary larvae (14.9 mm, SE = 1.10, n = 29; t = 0.76, df = 72, NS). There was also no significant difference in the number of ants per larvae between solitary larvae (mean = 3.6, SE = 0.3, n = 29) and larvae in aggregations (mean = 3.9, SE = 0.3, n = 45; t = 0.69, df = 72, NS), although the total number of ants in the general vicinity of a larva will be greater for larvae in aggregations. This may be important if effective ant protection from enemies requires rapid recruitment of workers.

The complex ecology of species with mutualistic associations highlights how the conservation of one species may depend critically upon the persistance of other species, which may not be more generally threatened. For example, the long-term persistence of the population of *P. c. zephyrus* at Sherbrooke Forest will depend on the presence of appropriate Acacia food plants, their attendant ant *Anonychomyrma* sp. near *foetans* and the proximity of large canopy eucalypts that may provide refuge sites for the pupae and resources for the ants. The ants and plants are robust species that can survive independently, but the viability of *P. c. zephyrus* depends critically on their combined presence.

Acknowledgements

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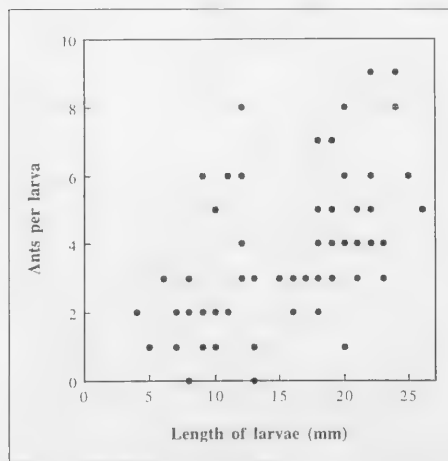
Fig. 1. The number of tending ants *Anony - chomyrma.* sp. near *foetans* per larvae of *P. c. zephyrus* and the size of the larvae; larger larvae are tended by significantly more ants (r = 0.49, n = 74, P < 0.01). The data are derived from two surveys of 37 solitary and aggregated larvae.

The Biology, Ecology and Horticultural Potential of Banksia L.f.: A Bibliography of Recent Literature

A.K. Cavanagh[1]

This bibliography covers papers published mainly between 1992 and 1995. It brings the total number of books and papers listed since I began my surveys in 1989 (Cavanagh 1989, 1994) to in excess of 330. While studies of reproductive biology and ecological studies continue to predominate, the considerable interest in the horticultural use of banksias has seen continuing fundamental and applied research being undertaken in this area. However, of major concern are the increasing prevalence of *Cryptodiaporthe* canker in major banksia populations in Western Australia and the fact that this, *Phytophthora cinnamomi* and commercial picking of banksias in the wild are all impacting adversely on native populations. There is certainly the need for more banksias to be grown in commercial plantations.

Most of the items listed are published in readily obtainable books and journals. However, in the interests of completeness, additional references from specialist database searches and from authors are included. Some of these are not easily accessible. The resultant bibliography is thus very comprehensive for the period 1992-1995. It also contains important references omitted from the earlier surveys.

The bibliography is arranged alphabetically by author under the following categories:-

Books on Banksias, General Works, Taxonomy, Reproductive Biology: *Pollination - General, Pollination - Birds and Mammals, Flower and Seed Predation and Seed Loss, Seed Development and Canopy Storage, Mechanisms of Seed Release, Seed Germination*. **Ecology**: *General Studies, Role of Fire, Role of* Phytophthora *and other Plant Pathogens*. **Rare and Endangered. Horticulture**: *General Studies, Propagation, Cultivation and Chemical Studies*.

Numbering follows on from the previous bibliography (Cavanagh 1994). All

Banksia taxa recognised by Taylor and Hopper (1991) and subsequent revisions are listed in the appendix. Each taxon is indexed to relevant papers in the bibliography. Thirty five of the 93 species, sub species and varieties are referred to in papers in the bibliography, the most 'popular' species being *Banksia hookeriana* with 10 papers. Nevertheless, there are still many species on which few or no studies have been made, notably the declared rare species *B. oligantha* and *B. sphaerocarpa* var. *dolichostyla* and most of the five on the W.A. Reserve Flora List of possible endangered species. More consideration should be given to these unstudied species in future projects.

Acknowledgements

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Appendix

Listing of all *Banksia* species (sensu Taylor and Hopper 1991 and other revisions). Species are indexed to relevant papers.

Dawsonia Polytrichoides Goes West?

Jon Sago[1]

A disjunct population of the moss *Dawsonia polytrichoides* R.Br. has recently been discovered at Eltham, Victoria. This is 90 km. west of its previous limit of distribution, the upper Bunyip River

Dawsonia polytrichoides is a robust, dioecious, acrocarpous species that grows normally to 10 cm. tall (Fig 1). Endemic to Australia its distribution ranges from North Queensland along the east coast to West Gippsland. It is typically associated with wet and dry sclerophyll forest (Scott and Stone, 1976), possessing a strong preference for disturbed habitats such as Lyrebird scratchings, the butts of dead trees and roadside gutters and embankments.

From personal observation and herbarium data it is restricted to altitudes between 100m and 900m and rainfall over 750mm p.a. Its presence at Eltham is consequently considered to be anomalous.

The site has a southerly aspect, situated in Westerfold's Park adjacent to the Yarra River, 17km. from Melbourne. It is 40m. above sea level and receives 610 mm of rainfall annually (Bureau of Meteorolgy, 1992).

The moss is growing beneath a dense copse of 3m. tall Burgan (*Kunzea ericoides*), surrounded by an overstorey of *Eucalyptus melliodora*, *E. viminalis* and *Bursaria spinosa*. The even-aged copse is senescent, composed of many collapsed and prostrate branches. It is estimated to be approximately sixty years old (*pers. comm.* L. Pittle), probably produced by a single wildfire event.

It is evident that the deep shade provided by the copse has ameliorated the local climate allowing a rich bryological diversity to develop over the decades, far greater than that of the surrounding dry sclerophyll forest of the lower Yarra valley. Amongst the terricolous species are, *Dicranoloma billardieri*, *Ptychomnium aciculare*; and the corticolous species *Sematophyllum homomallum*, *Frullania falciloba*, *F.clavata* and *Metzgeria decipiens*. All of these species have a natural distribution that is highly resticted within the Melbourne region.

Physiologically *D.polytrichoides* is adapted

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to drought, with unique leaf hinge movement (where the leaf can radically alter from a lateral to a recurved position), inrolling and spiral twisting once dessicated (Zanten,1973). It is in this state at Sweeney's Lane that *D.polytrichoides*, apart from recent rain periods, is usually found, appearing blackened, withered and dead.

Dawsonia polytrichoides is represented at the site by three discrete mats of perhaps 1 m.sq. each. It is of interest that sporophytes are absent and all three mats are male gametophyte clones. As the only method of dispersal in *Dawsonia* is by spore, vegetative propagation being unknown in the genus (Zanten,1973), it is highly likely that only three male spores are responsible. This absence of female gametophyte individuals, and the concomitant sexual process, is considered to indicate in bryophytes that the individual plants may be growing at their ecological limit (Schofield and Crum,1972).

As February, for Melbourne, is the month of lowest average rainfall and culminates two months of highest average evaporation and temperatures (Fig. 2), it is the period most critical for bryophyte survival. A perusal of Fig. 3 would indicate a correlation

Fig. 1. *Dawsonia polytrichoides* R.Br. Photo. R.Sago.

between February rainfall greater than 50mm and the distribution of *D. polytri-choides*. In particular its absence from the Dandenong Ranges, an area one would intuitively consider as ecologically suitable due to its annual rainfall and altitude, is explained, as it receives substantially less February rainfall than Gippsland, immediately to the east. However, this apparent correlation does not fully explain its absence from the western Victorian areas of the Ballarat Highlands or Otways,
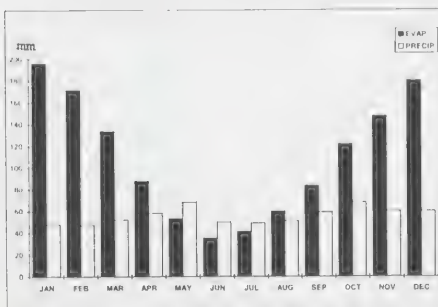

Fig. 2. Monthly Average Distribution of Rainfall and Evaporation for Melbourne.

where significantly *D.superba*, a closely related and even less drought tolerant species has been collected.

There are also two tantalising historical reports that confirm this western limit. An eastern Mornington Peninsula site has been reported to share a similar disjunction (*pers. comm.* G. Scott) though its continued existence and exact locality are unfortunately unknown as herbarium data are lacking. A MEL specimen, without capsules, collected by F.M.Reader from 'Oakleigh' in 1884,which would of also shared a similar longitude is an historical confirmation and a glimpse into an ecological situation no longer with us.

There is palaeoclimatological evidence that world temperatures are rising (Williams, 1994) and, more pertinently, precipitation/evaporation ratios have been declining in south-western Victorian over the last 100 years (De Deckker, 1982). As the geographical distribution of *D.polytri-choides* is apparently limited by summer rainfall it may prove to be a useful indicator species in any analysis of climate change in Australia.
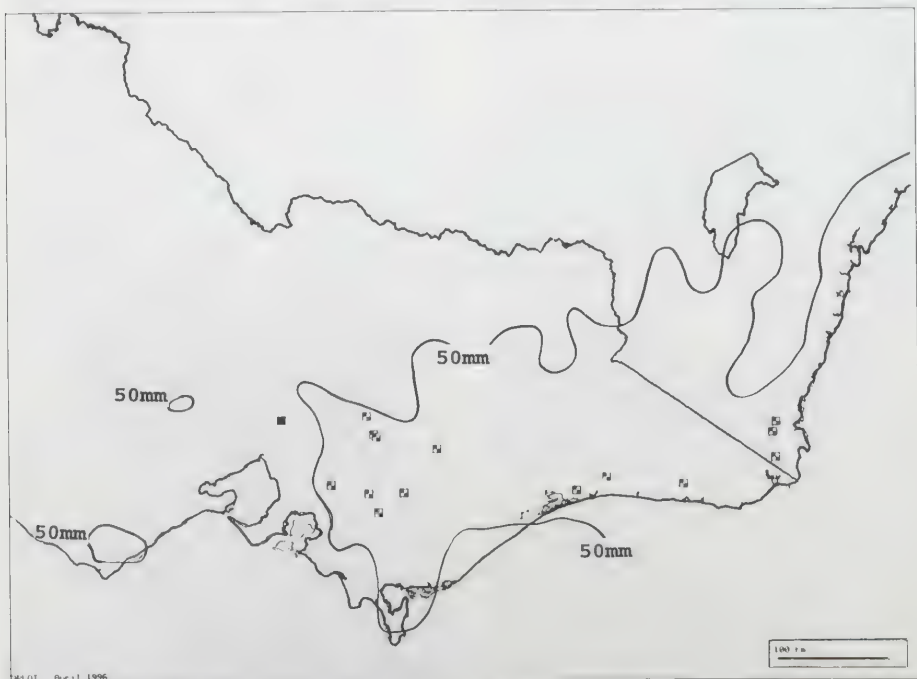
Fig. 3: The distribution of *Dawsonia polytrichoides* in S.E. Australia.
Key : / = the Feburary 50mm average rainfall isohyet; ■ = Sweeney's Lane, Eltham; ▇ = Recorded sites MEL and MELU data

Assuming the inevitable death and fragmentation of the Burgan copse at Westerfold's Park, continued survival of *Dawsonia,* even in the medium term, is doubtful in the Melbourne area.

Acknowledgments:

This article could not have been written without the assistance of Lisa Pittle, who was instrumental in alerting me to the value of the Sweeney Lane site; Arthur Theis with invaluable taxonomic opinion; the staff of MEL and MELU herbaria and the staff of the Arthur Rylah Institute with computer mapping.

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Bell-fruit or *Codonocarpus*

Scattered throughout the drier parts of Australia, in all states except Tasmania, is a small genus, *Codonocarpus*. It belongs in the family Gyrostemonaceae, so named from the Greek *gyros* (a ring) and *stemon* (a stamen) referring to the whorls of stamens in the male flower. Sometimes the male and female flowers are on the same tree, sometimes male and female are separate.

The small tree, Bell-fruit Tree or Native Poplar *Codonocarpus cotinifolius*, sometimes little more than a shrub, is scattered, in isolated areas in north-west Victoria, in the mallee scrub and usually on higher sandy habitats.

On the rare occasions it is seen, it is very obvious for two reasons. One is the distinctive leaf color, usually grey-green, and the other the pyramidal or conical general shape.

In season there is another characteristic from which the genus name *Codonocarpus* is derived, *codon* (a bell) and *carpos* (a fruit). This refers to the bell-shaped fruit, about one centimetre in diameter, borne on the upper branches. Each fruit consists of between 30 and 50 segments which eventually separate to release a reddish seed.

The species name *cotinifolius* is derived from a supposed resemblance of the leaves to *Rhus cotinus*. This is in reference to their pungent nature. If crushed in the fingers there will be a lingering taste of horse-radish which will persist even after the hands have been washed. The plant is rarely eaten by stock, probably for this reason, lives only for a few years, and regenerates rapidly after fire.

The specimen illustrated in the accompanying photograph was seen in a small clump in the Murray-Sunset National Park, a few kilometres south from Rocket Lake.

Bell-Fruit *Codonocarpus cotinifolius,* in the Murray-Sunset National Park, Mopoke Hut Track.

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From our Naturalist in Residence, Ian Endersby

The Editors are pleased to welcome Ian Endersby as our 'Naturalist in Residence' for 1997. He will be writing a series of articles on his natural history observations. The first article is presented in this issue.

Proliferating Fungi

If you blow up a balloon, place it on the edge of a table, and give it a sharp whack from behind it follows a path that it is not the parabolic one that you would expect from the laws of gravity. It moves out horizontally and then drops somewhat vertically. This is exactly the path that a fungal spore takes when it is ejected from a basidium on the face of a gill in one of the agaric fungi. In fact, the track that it follows has been named a sporabola and the story and mathematics are well told in C. Ingolds' book 'Spore Liberation' (Clarendon Press: Oxford 1965).

It is easy to visualise a vertical gill with the spore shooting horizontally and then falling vertically in the space between the gills. If the spore travels too far before dropping it will land on the opposite gill and have no chance of developing, so the space between the gills and the length and shape of the sporabola have a carefully evolved relationship. If you have an agaric in front of you look at its gills, or if you do not, imagine them anyway. Because the gills radiate from the stipe they become further apart as they approach the outer edge. This is inefficient from a reproductive point of view. If the distance between the gills matches the sporabola where the gills are close together near the stipe it will be far too wide near the edge. Most agarics have a shorter intercalated gill occupying that spare space near the edge thus providing additional surface area for basidia to form which enhances the spore production capacity of the species. In some cases a third rank occurs. One of the most interesting studies about the fungi is to consider the numerous ways in which evolution has maximised the hymenial surface, and the various methods used to disperse the spores.

With agarics we can see that the short additional gills increase the spore production area and it is not too big a step to envisage cross gills which would give

even more. This is found in the pores or tubes found in polypores and boletes. Convergence has duplicated structures in distantly related groups through the pressure to maximise spore-bearing tissue. A nice example is the bracket fungus *Hexagonia* with its hexagonal pores. These maximise the spore surface but minimise the sterile tissue between and so produce a structure that looks like that which the honeybee builds when it minimises wall volume in the most efficient manner.

Thelephores have a wrinkled surface which, compared to a flat equivalent, increases the surface area. The Coral fungi, that have a proliferation of stalks and arms where the hymenium is on the outer surface, are further examples of evolution at work to flood the environment with spores. Gasteromycetes, particularly the puffballs, don't have an external hymenial surface but they have an enormous area of spore-bearing tissue within the peridium. Gasteromycetes also show the most diverse methods of distributing spores but there is one other point that we should recognise before we consider their methods.

Even when the wind blows strongly there is a thin layer of air close to the surface which exhibits laminar flow. For good dispersal spores must be ejected into the turbulent air above this. Stalked and coral fungi drop their spores directly into the turbulent layer while cup fungi and other flat forms need to explosively eject their spores through the laminar layer into turbulent air.

Raindrops falling on to the parchment-like skin of the puffball *Lycoperdon,* or any of the earthstars (*Geaster*), puff spores out through the ostiole and beyond the laminar layer. *Calostoma* is a stalked puffball which has an ornamented ostiole and it is interesting to speculate why this is necessary if a plain one is adequate for all other puffballs that are activated by rain-

drops or other external pressures. Perhaps the shape of the ornamentation allows spores to be sucked out by a venturi effect as the wind blows past the mouth. *Scleroderma* and *Pisolithus* weather away and liberate their spores over a period of time.

I have often searched for, and once or twice found, Bird's Nest Fungi - tiny cups with packets of spores in them called peridiola. They look just like their common name suggests and this likeness gives the generic names *Nidula* or *Nidularia* to many of the species. The diameter of the cup is sized to be just right for an impinging raindrop to splash the spore packets out into the air. Attached to the peridiolum is a long cord of hyphae called the funiculus which has a sticky end to it. When the flying peridiolum approaches any vegetation the sticky funiculus catches and the momentum of the spore packet is sufficient to wrap the cord around the vegetation. Here it awaits ingestion by a grazing animal. This is necessary for it to complete its life story.

Space does not permit further examples of fungi that disperse through the digestive tracts of animals but keeping some droppings or scats under humid conditions will allow you to make your own inventory. However, there is one more group that fascinate me, and their story must be told. *Clathrus* is a genus of the gasteromycetes which emerges from a puffball like structure and expands into a spherical, white lattice. Spores are contained in a foetid brown-green slime that covers the ball. I have photographed specimens in the mulch of my own garden. A similar spore mass is found on the Starfish fungus *Aseroe rubra* that I associate with trips to the Alps. In both of these species, and in other members of the Phallales to which these two belong, the rotting meat smell of the spore mass is sufficient to attract flies which crawl around the fungus and inadvertantly collect the spores on their legs. These are then carried away and will be dispersed when the fly cleans the mess from its legs. I have never seen fly blown examples but that is quite feasible as the cactus genus *Stapelia* uses a similar mechanism to achieve fertilisation, and I have seen them crawling with maggots. What the advantage is to the fly I have not worked out.

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Field Guide to the Birds of Australia
(Fifth Edition)

by Ken Simpson and Nicolas Day

Publisher: *Penguin Books Australia Ltd, 1996;*
400 pp. numerous colour and black-and-white illustrations and distribution maps
RRP $35.00.

In this, the fifth edition, 19 colour plates have been replaced and two modified, the Field Information section has been re-ordered and scientific and vernacular names updated to conform with taxonomic change, distribution maps have been adjusted and 154 extra or replacement black-and-white drawings have been included. In addition, abundance and movement codes for each species have been introduced for the first time but, in some cases, with limited success. This 'field' guide is still too bulky and broad and would improve markedly if it was photo-reduced in size and if parts of the handbook section were omitted as previously outlined in Silveira (1994). This edition has commendably been printed in Australia, previously Hong Kong, but the price has, unfortunately, increased from $29.95 to $35.00 (cf Slater *et al.* 1989: $29.95 to $35.00; Pizzey 1991: $24.95 to $29.95). Even at the new price, it is still well worth purchasing if one does not already possess the previous edition.

The following improvements and corrections are suggested:-

Key to Families: Several of the family names and descriptions should be aligned with the appropriate illustrations to avoid confusion: 'Mihirungs', 'Quails, Pheasants', 'Grebes', 'Herons, Egrets, Bitterns', 'Ibises, Spoonbills', 'Flamingos', 'Palaelodids', 'Phalaropes', 'Sittellas', 'Treecreepers', 'Fairy-wrens' and 'Pardalotes, Bristlebirds, Scrubwrens, Gerygones, Thornbills'.

Field Information: a bold-type sub-heading such as 'Remarks' or 'Other comments' is still required after 'Habitat' for many of the species. The abundance code is said to represent 'abundance of the species' and should thus reflect the density of a species over its range. However, in most cases it actually reflects the 'observability' of a species. Consequently, species with vastly different densities and popula-

tion sizes have been bracketed under the same abundance code. For example, the Powerful Owl, which is relatively easy to observe due to its conspicuous far-carrying call and its habit of routinely roosting in the same area, is bracketed with the Superb Lyrebird, the Shy Heathwren and the Scarlet Robin under the abundance code, 'MC (Moderately Common)'. On a global scale, however, the Powerful Owl has a 'small and declining population' (see Table 4, Collar *et al.* 1994) which easily qualifies for 'Vulnerable' status (fewer than 10,000 mature individuals) and quite possibly qualifies for 'Endangered' status (fewer than 2,500 mature individuals) suggesting that it should, more appropriately, be ascribed the abundance code, 'R (Rare)'. This general problem is repeated for many other species with 'small' global or Australian populations (e.g. Sooty Owl, Sooty Oystercatcher, Superb Parrot, Painted Snipe, White-bellied Sea-Eagle and Painted Honeyeater) and unfortunately conveys the wrong impression about their status. A possible solution is to have an abundance code based on estimated densities [e.g. **Abundant:** 1 or more individuals/ha (=100 or more/km^2), **Common:** 1-9 individuals/10 ha (=10-99/km^2), **Moderately Common:** 1-9 individuals/km^2, **Uncommon:** 1-9 individuals/10 km^2 (=10-99/100 km^2), **Rare:** 1-9 individuals/ 100 km^2, **Very Rare:** less than one individual/100 km^2] and a separate 'observability' code based on the ease of observation.

2 Southern Cassowary: insert 'flightless' in the text; 'Juv.' and 'Imm.' in the text but '1st year' in the plate; hatchling is 'striped yellow, black' in the text but 'chick' is striped white and dark brown in the plate. **3** Emu: distributions of the three races are not indicated on the map. **14** California Quail: should be *californica* not *californicus*.

15-21 Button-quail spp: an important identification feature, voice, should be

included. **32** Little Penguin: trinomial is not required. **045** Antarctic Petrel: should be numbered '45' not '045'. **48** Great-winged Petrel: races should be labelled on the plate. **66** Fulmar Prion: should not be numbered '66' but left blank if 'Aust. record suspect'. **67** Fairy Prion: 'no central black' undertail in the text but darkish central undertail in the plate. **72** Flesh-footed Shearwater: 'tail rounded' in the text but more wedged in the line drawing. **77** Streaked Shearwater: 'head white' and 'tail rounded' in the text but white forehead and a more wedged tail in the plate. **95** Red-footed Booby - Dark morph: 'all brown' in the text but white rump, tail and abdomen in the plate. **96** Masked Booby: white left eye spot in the line drawing of the race *personata*. **101** Red-tailed Tropicbird: map should be labelled morphs not races. **104** Black-faced Cormorant - Imm.: 'eye brown' in the text but green in the plate. **111** Australasian Grebe - Imm.: may easily be confused with 'non-breeding' not 'breeding' Hoary-headed Grebe. **113** Black Swan - Imm.: 'with' repeated in the text. **130** Freckled Duck: abundance code should be 'R-LMC' not 'R-MLC'. **134** Musk Duck: makes a 'plonk' sound during display. **145** Tasmanian Native-hen: 'legs yellow' in the text but dark grey in the plate. **147** Dusky Moorhen - Nestling: 'frontal shield red' in the text but yellow in the plate. **148** Purple Swamphen: insert 'flicks tail nervously' in the text. **159** Striated Heron: border between races on the map contradicts distributions given in the note. **167** Straw-necked Ibis: 'legs black' in the text but reddish in the plate. **173** Australian Bustard: resident population in the southern Big Desert / Telopea Downs area of Victoria is not shown on the map. **174** Plains-wanderer: distribution is too restricted for Victoria where it is also known to breed (Bennett 1983). **176** Eurasian Curlew: 'no eyebrow' in the text but the 'in flight' illustration appears to have one. **177** Eastern Curlew: 'pale eyebrow' in the text is not apparent in the plate. **201** Sharp-tailed Sandpiper: Juv. should be described. **202** Pectoral Sandpiper: Juv. should be described. **205** Western Sandpiper: should not be numbered but left blank if 'Doubtful in Australia'. **207** Red-necked Stint: Juv.

should be described. **209** Curlew Sandpiper: Juv. should be described. **211** Sanderling: black shoulder patch in non-breeding plumage should be mentioned in the text. **213** Broad-billed Sandpiper - Non-breeding: 'Dark shoulder patch' in the text but not in the plate. **215** Stilt Sandpiper: 'long yellowish legs' in the text but greenish in the plate. **224** Bush Stone-curlew: 'whitish shoulder patch' in the text but not in the plate. **232** Eurasian Golden Plover: should not be numbered but left blank if 'No claimed Aust. sighting'. **236** Little Ringed Plover: breeding plumage should be described. **249** South Polar Skua: ventral 'in flight' illustration should be labelled '249 Light morph'. **250** Arctic Jaeger - Dark morph breeding: 'yellow collar' in the text but not in the plate. **253** Silver Gull: Imm. should be described. **257** Franklin's Gull: 'Imm.' in the text but 'Juv.' in the line drawing. **260** White-winged Black Tern: 'almost square tail' in the text appears clearly forked in the plate. **269** Sooty Tern: eyebrow of the standing bird in the plate is too long. **274** Lesser Crested Tern: breeding plumage should be 'frons' not 'front' black to bill; size is required. **277** Black Noddy: should be black 'lores' not 'frons'. **278** Grey Ternlet: illustrations in the plate should be labelled with the appropriate morph. **284** Square-tailed Kite: distribution should include all of Victoria; habitat should include tall open-forests; migratory not nomadic in Victoria (Debus and Silveira 1989). **287** Whistling Kite: 'in flight' underwing is too dark. **298** Black Falcon: map should not show two isolated breeding populations in W.A. **299** Peregrine Falcon: distributions of the two races *submelanogenys* and *macropus* are not indicated on the map. **300** Australian Hobby: distributions of the two races *longipennis* and *murchisonianus* are not indicated on the map. **302** Brown Falcon: five 'races' mentioned in the text whereas three 'colour morphs' and 'apparent intermediates' are discussed in Marchant and Higgins (1993); four 'races' are illustrated on one plate (p. 121) but a dark 'morph' on another (p. 119); the 'in flight' *tasmanica* looks like the perched *berigora*. **303** Nankeen Kestrel - Female: 'dark tear drop mark under eye' should be deleted as it is not a unique feature of that

gender. **321** Brush Bronzewing: habitat should include tall open-forests and open-forests especially on the coastal side of the Great Dividing Range in Victoria (e.g. LCC 1982, p. 43; LCC 1985, p. 275; LCC 1991, p. 377). **325** Partridge Pigeon: should comprise two morphs or two races but not both. **326** White-quilled Rock-Pigeon: should comprise two morphs or two races but not both; illustrations not labelled. **328** Spinifex Pigeon: 'Race' in the text but 'morph' in the plate. **334** Short-billed Black-Cockatoo: perched and 'in flight' colour illustrations still required. **339A** Little Corella: line drawing should be labelled 'Little Corella' not 'Race *sanguinea*'. **395** Rufous Owl: size of both sexes required. **396** Powerful Owl: habitat should include open-forests and woodlands; size of both sexes required. **397** Southern Boobook: right-hand illustration in the plate could be labelled pale 'form' or 'phenotype' instead of 'race'; size of both sexes required. **398** Barking Owl: size of both sexes required. **399** Brown Hawk-Owl: 'indistinct facial mask' in the text but not apparent in the plate. **400** Sooty Owl: should not still be labelled 'Light morph' in the plate. **402** Masked Owl: morphs in the text but still labelled races in the plate. **407** Marbled Frogmouth: appears markedly sexually dimorphic in size in the plate. **424** Sacred Kingfisher: upper illustration in the plate should be labelled 'Imm.'. **431** Blue-winged Pitta: 'white throat' in the text but buff strip on the throat in the plate. **437** Noisy Scrub-bird - Juv.: correctly shows cinnamon throat and chest in the plate but not mentioned in the text. **438** Varied Sittella: race *pileata* occurs in western Victoria; map should be labelled race '*leucocephala*' not '*leucophala*'. **441** White-browed Treecreeper: insert 'identify with care from Brown Treecreeper' as it is routinely and erroneously reported from areas in north-western Victoria now inhabited only by Brown Treecreepers (e.g. Hattah-Kulkyne N.P.). **446** Superb Fairy-wren: male 'tail dark blue' in the text but purple in the plate. **447** Splendid Fairy-wren: comparative 'in flight' illustration (p. 168) should be labelled '447 Race *splendens*' not '447 Splendid Fairy-wren'. **448** Variegated Fairy-wren: distribution of the race *lamberti* should extend southward

almost to the Victorian border (Emison *et al.* 1987). **455** Mallee Emu-wren: S.A. distribution is exaggerated as much of that area has been cleared; Victorian distribution includes Murray-Sunset N.P. east to Hattah-Kulkyne N.P. and the Big Desert east to Wyperfeld N.P. **456** Rufous-crowned Emu-wren: delete 'sometimes in adjacent or associated mallee scrub'. **461** Eyrean Grasswren: correctly shows thick pale blue-grey bill in the plate but not mentioned in the text. **471** Rufous Bristlebird: known distribution of the now possibly extinct race *littoralis* should be indicated on the map. **487** Speckled Warbler - Female: correctly shows reddish-brown streak above the white eyebrow in the plate but not mentioned in the text. **492** Brown Gerygone: distribution should extend westward well into Victoria (Emison *et al.* 1987). **493** Western Gerygone: too brown in the plate, should be greyer. **521** Regent Honeyeater: bare facial skin may vary in colour from yellow to pink (Franklin and Menkhorst 1988); colour illustration of Juv. required as it differs from adult plumages. **515** Spiny-cheeked Honeyeater: colour illustration should not have a pink eye-ring. **528** Black-eared Miner: 'Cannot be reliably identified in the field' has commendably been inserted into the text; distribution should still be amended as all 13 of the known specimens are from south of the Murray River in S.A. and Victoria (e.g. Silveira 1995) or, alternatively, should clearly be stated to include intergrades and thus, in Victoria, extend southward to include the Big Desert and eastward to include the Annuello Flora & Fauna Reserve. **550** White-plumed Honeyeater: habitat should include 'suburbs'. **551A** Black-chinned Honeyeater: 'dart' highlighting the blue eye-skin is difficult to see. **554** White-throated Honeyeater: 'white nape line extends almost to the eye' in the text but not in the plate or the line drawing. **560** White-fronted Honeyeater: delete 'rump rufous'. **565** Painted Honeyeater: NT distribution should extend north to the Roper River area (Blakers *et al.* 1984). **587** Western Whipbird: only two races discussed in contrast with Schodde & Mason (1991) who consider that four exist. **594** Grey-crowned Babbler: distribution

exaggerated for Victoria where it has declined markedly. **598** Rose Robin: should be white 'frons' not 'front' in the text. **603** Hooded Robin - Female: insert 'identify from Jacky Winter' in the text. **606** Western Yellow Robin: appears to be much smaller than Eastern Yellow Robin in the plate even though the size is given as '15 cm' for both. **616** Pale Yellow Robin: lower colour illustration should be labelled 'Race *capito*'. **617** White-browed Robin: upper colour illustration should be labelled 'Race *superciliosa*'. **620** Little Shrike-thrush: should be labelled race '*rufigaster*' not '*megarhyncha*' in the plate. **622** Sandstone Shrike-thrush: race *didimus* should be described. **623** Grey Shrike-thrush: race *strigata* should be described. **624** Golden Whistler: Imm. and female in the plate are too brown, should be greyer. **625** Mangrove Golden Whistler - Female: race *robusta* 'tail black' in the text but brown in the plate; race *melanura* should be labelled in the plate. **634** Mangrove Grey Fantail: colour illustration still required. **643** Black-faced Monarch - Juv.: bill 'black' in the text but grey in the plate. **648** White-eared Monarch: 'Juv.' in the text but 'Imm.' in the plate. **650** Spangled Drongo: 'Juv.' in the text but 'Imm.' in the plate. **651** Yellow Oriole - Juv.: bill 'brownish' and eye 'grey brown' in the text but pinkish and reddish respectively in the plate. **652** Olive-backed Oriole - Juv.: bill and eye 'dark' in the text but reddish in the plate. **653** Figbird- Female: facial skin 'bluish' in the text but dark brown in the plate. **663** Regent Bowerbird: 'in flight' line drawing should be labelled male not female. **670** White-bellied Cuckoo-shrike: does not occur in the Victorian Mallee Region south of Murray River riparian habitats; race *stalkeri* should be described. **673** White-winged Triller - Male breeding: 'light grey rump' in the text but not so in the plate. **674** Varied Triller - Male: 'dark grey rump' in the text but not so in the plate. **675** White-breasted Woodswallow: breeding distribution should include the Murray Valley region of Victoria (Emison *et al.* 1987). **685** Australian Magpie: race *tibicen* and intergrades occur across a broad band of northern Victoria; line drawings should be labelled 'males'. **686** Pied Currawong: ventral 'in flight' aspect should be shown in the plate as dorsal 'in flight' aspect is already shown in the line drawing. **688** Grey Currawong - race *versicolor*: ventral 'in flight' aspect should be shown in the plate as dorsal 'in flight' aspect is already shown in the line drawing; boundary between races *melanoptera* and *howei* in the Victorian Mallee region is fanciful: race *howei* should be described. **700** Tree Martin: ventral 'in flight' illustration is too brown; should be slightly but noticeably larger than the Fairy Martin in the line drawing and in the plate. **707** Singing Bushlark: 'Imm.' in the text but 'Juv.' in the plate. **723** Double-barred Finch: upper illustration in the plate should be labelled 'Race *bichenovii*'. **726** Masked Finch: upper illustration in the plate should be labelled 'Race *personata*'. **730** Red-browed Finch - Juv.: should be 'no eyebrow' not 'eyebrow shorter' in the text. **734** Diamond Firetail: left-hand illustration in the plate should be labelled male. **735** Painted Finch - Female: 'red bill, lores' in the text but not so in the plate. **741** Gouldian Finch - Juv.: lower bill 'white' in the text but blackish in the plate. **742** Yellow-bellied Sunbird: colour of upper-parts differ between one plate (p. 175) and another (p. 273). **743** Mistletoebird: 'Juv.' in the text and one plate (p. 273) but 'Imm.' in another (p. 175); Juv. 'bill, gape orange' in the text but not so in the plate. **749** Russet-tailed Thrush: should be smaller than the Bassian Thrush in the plate.

Glossary: The given species definition suggests that members of a species 'can interbreed among themselves' and is consistent with the 'lumping' of some interbreeding forms (e.g. Spotted and Yellow-rumped Pardalotes, Mallee and Port Lincoln Ringnecks, the Sittellas, Masked and Spur-winged Lapwings, Crimson, Yellow and Adelaide Rosellas and Yellow and Green Figbirds), but is inconsistent with the retention as species of other interbreeding forms (e.g. Eastern and Pale-headed Rosellas, Yellow-throated and Black-eared Miners and Brown and Inland Thornbills).

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Australian Frogs

by the Australian Museum

Publisher: *Australian Museum, 6 College Street, Sydney, NSW 2000;*
IBM compatible, 3.5 inch disc, RRP $15.00 (plus postage);
Available through the Australian Museum Shop.

The Australian Museum Information Disc on Australian frogs comes on a single HD3.5" floppy with an attractive wrapper that gives essential information on content and use. The program needs to be installed on a PC with Windows 3.1, 3 Mb disc space free and 256 colours (it also needs to be a 386 system.

The program is easy to operate. It starts with a *contents* screen which contains five sections about frogs; diversity, disappearances, life cycle, biology and habitat.

The diversity section gives textual information about a couple of representative frogs from each of 16 different informal groups. It is not made clear what distinguishes the groups (habitat, appearance, taxonomy?). Explaining this would help to clarify what is meant by diversity of the frogs. The species chosen are from NSW and Qld. Only a few Victorian species are represented, and only one from WA. For each group there is textual information, and, on a separate screen, a colour photograph. Unfortunately the picture can take up to 30 seconds to appear on a 486 student laptop.

The section on disappearing frogs is up-to-date, but again only considers NSW and Qld frogs. Maps are included for the Qld frogs.

The frog facts section is a great resource for current information on herpetological societies, and for further reading, especially on disappearing frogs. Complete lists of common and species names are also included.

The software is too simple by current standards; better use could be made of computer technology. Images seem to be left compressed after installation and perhaps this contributes to the excessively long time taken to display some images. Not enough use is made of the computer's ability to cross-connect information, show movement or animation or to play sound.

The information is authoritative, accurate and useful. However, it would be better titled Frogs of North-east Australia.

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The Victorian Naturalist

F.N.C.V.

Mistletoes in the Australian Landscape

Spotlight on Mistletoes

An Introduction to Papers from the Mistletoe Forum, 1996

Continental Australia has at least 84 species of mistletoe and 12 of these (14%) are found in Victoria. Mistletoes are widespread across all native forest and shrubland communities in Australia - from coastal mangroves to tall ash forests in highland Victoria, and from mulga to mallee. Mistletoes are also common along roadsides and in rural landscapes. Surprisingly, there are no mistletoes in Tasmania.

Australians have not adopted the Christmas cultures of Europe or north America where mistletoe is an important part of festivities. Kissing under the mistletoe has grown from ancient beliefs that the evergreen mistletoe, which carries its ripe berries in the middle of winter, was a symbol of vitality and fertility and a medium to ensure conception and childbearing. There is no tradition of mistletoe kissing in Australia and there is no evidence that the Australian population is any the less fertile.

Clearly, mistletoes are part of the rich biodiversity of Australia and they play an extremely important role in the food supply of several native birds, possums and insects; they form sheltered and shady nesting and resting sites for birds and small mammals; and they contribute significantly to the beauty of the bush. In certain situations they can cause damage to trees, and they have been associated with tree decline, and even tree death in parts of rural Victoria. In Melbourne's gardens and along many streets, the native Creeping Mistletoe is a fairly common sight on introduced, deciduous trees. While these mistletoes may be considered unsightly during winter, they do not usually cause serious damage and, remember, they are an important source of nectar for some native birds which depend on them. Mistletoes should be better understood and managed in ways which ensure that they can fulfill their ecological role in the Australian bush.

Recognising this need, the Field Naturalists Club of Victoria decided to hold 'A Forum on Mistletoes' during 1996. The Forum was presented in four distinct activities spread over the year:
1. A practical workshop on the biology and identification of mistletoes;
2. A presentation by experts on mistletoe biology;
3. A field excursion to see mistletoes and their hosts; and
4. Production of this special issue of *The Victorian Naturalist* in which the Forum papers are published.

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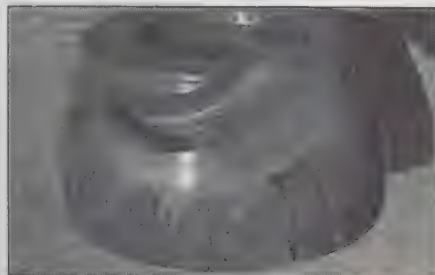
Fig. 1. Haustorium of *Amyema pendula*. Photo: M Calder.

Fig. 2. Bowl made from Mistletoe haustorium. Photo: M Calder.

The
Victorian
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Articles from the Mistletoe Forum

Cover: The male Mistletoebird feeding young. Photo courtesy F. Morrison

The Mistletoe Plant

Malcolm Calder[1]

Mistletoes fall into one or other of two families of flowering plants, the Loranthaceae and the Viscaceae. These two families are taxonomically related to each other and share this relationship with the Santalaceae (Cherry Ballart and Quandong) and the Olacaceae (Olax), all of which have a habit of root parasitism. Mistletoes are predominantly, but not exclusively, stem parasites.

The Loranthaceae, as indicated by Brian Barlow in 'Flora of Australia' Vol 22, is widely distributed in the tropics, but extends southwards to south temperate climates. There are a total of around 65 genera and 950 species. In Australia there are 12 genera and over 80 species, 60 of these are endemic. Interestingly, there are no mistletoes of either family in Tasmania, yet they are both represented in New Zealand. The family Loranthaceae is considered to be an ancient Gondwanan one which was well established before the break up of the southern continents. It is suggested that the root parasitic mistletoes like *Nuytsia* (West Australian Christmas Tree) and *Atkinsonia* of New South Wales, are the more primitive members of the family in Australia. Barlow also considers that those species which do not have high specificity with regard to their host requirements (e.g. *Muellerina*) are also primitive and have their origin in Gondwana. There are several more advanced mistletoes which have high host specificity and complex inflorescence. These are considered to be relatively recent re-invasions from the north as Australia pushes into south-east Asia.

The Viscaceae is well represented in the tropics of both hemispheres, extending north and south into cool-temperate climates. The European mistletoe of Christmas fame (*Viscum album*) grows as far north as Sweden, but prefers the warmer summers of central and southern Europe. This family has seven genera and 400 species world-wide. In Australia there are three genera and 14 species, seven of which are endemic. There are two species

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of this family in Victoria: Golden Mistletoe *Notothixos subaureus* and Jointed Mistletoe *Korthalsella rubra*.

All mistletoes show some degree of parasitism and dependence on a host plant, and all, with the exception of *Nuytsia* and *Atkinsonia*, are epiparasitic shrubs. These have structures of varying morphology which penetrate to the water-conducting tissues of the host. There they develop an extended functional surface across which water and mineral nutrients pass from the host. In contrast, there is virtually no movement of sugars or manufactured food material from the mistletoe to the host. For these reasons mistletoes are frequently referred to as half parasites (hemiparasites), water parasites, partial parasites or aerial parasites.

In almost every habitat where mistletoes are found, a close association of the parasite with other organisms has been demonstrated. The first of these associations is with the host plant. Interestingly, mistletoes vary in the degree to which they are associated with particular hosts. Some, like the Creeping Mistletoe, can attack a wide range of host plants, including introduced deciduous trees, and these are considered to be amongst the more primitive species in the family. Others are more choosy about their host plant and will only grow on particular species. The mechanisms controlling these host preferences are not at all understood, but there is probably a physiological interaction at the cell level similar to the tissue rejection processes of organ transplants in humans. There are some mistletoes which seem to have a preference for growing on other mistletoes which creates an interesting parasitic sequence.

In Australia, several nectar-feeding birds depend on the Loranthaceous mistletoes for a supply of nectar. These birds are the primary vectors of pollen and are directly involved in the pollination process. So there is a clear mutual benefit to both parties in this relationship. At a later stage in the life cycle of the plant, ripe fruit are eaten by the Mistletoe Bird which is designed so that the seed passes through the digestive system

quickly and the developing plant embryo is placed on a branch where it will germinate and grow. In this association a bird is fed and the plant is dispersed to a new location and host. Clearly, birds are primary players in the life and ecology of mistletoes, and mistletoes comprise important food sources for a range of birds.

Mistletoe shrubs are often used as sites for nests or roosting places for both birds and mammals. Some evidence suggests that possums browse on the leaves of mistletoes. Probably the strongest browsers are the larvae of certain butterflies and

moths several of which only feed on mistletoe leaves. There are several interesting natural history stories about associations between insects and mistletoes.

Finally, like almost all species, mistletoes suffer from attacks by fungi and bacteria. Some of the leaf inhabiting fungi associated with mistletoes have been discussed in a paper from the forum.

All-in-all, mistletoes have a whole range of associations with many different types of organism. They make for a fascinating ecological and biological study - the ideal subject for a field naturalists forum.

The Mistletoes of Victoria

Name	Common Name	Main Hosts	Pest Status
Muellerina eucalyptoides	Creeping Mistletoe	Eucalypts and several other natives as well as other introduced trees	Could be a serious problem
Muellerina celastroides	Coast Mistletoe	*Banksia integrifolia* and some other coast plants	Not important
Amyema preissii	Wire-leaf Mistletoe	Mainly *Acacia* sp., recorded on *Cassia* sp	Could be a local problem, not serious
Amyema linophylla	Buloke Mistletoe	Species of *Casuarina* exclusively	At most, a local problem
Amyema quandang	Grey Mistletoe	Exclusively on species of *Acacia*	A serious problem, parasite of Acacias
Amyema miraculosa	Fleshy Mistletoe	*Santalum, Myoporum, Casuarina* and other Mistletoes	Not an aggressive parasite, can be locally abundant
Amyema pendula	Drooping Mistletoe	Mostly Eucalypts, but occasionally *Acacias*	Serious where heavy infestations occur
Amyema miquelii	Box Mistletoe	Usually Eucalypts of the Box group but also Acacias	Serious where heavy infestations occur
Lysiana exocarpi	Harlequin Mistletoe	Wide range in drier areas, including *Casuarina* and other Mistletoes	Not a problem species
Dendrophthoe vitellina	Long-flowered Mistletoe	Wide range especially within Myrtaceae	Not a Victorian problem
Korthalsella rubra	Jointed Mistletoe	In Victoria confined to Lilly-pilly	Perhaps endangered in Victoria
Notothixos subaureus	Golden Mistletoe	Restricted to other Mistletoes; in Victoria, the Long-flowered Mistletoe	A rare plant in Victoria

Mistletoes in Victoria

Neville Walsh[1] and Jeff Jeanes[1]

Abstract
The two families of mistletoe represented in Australia (Viscaceae and Loranthaceae) are compared and their evolutionary histories discussed. A total of twelve species of mistletoe are present in Victoria. A key to the identification of the Victorian species is provided, along with distribution maps and habit photographs. (*The Victorian Naturalist*, **114**, 1997, 98-104).

Introduction

There are 12 species of mistletoe in Victoria, occurring in six genera and two closely related families, the Viscaceae and the Loranthaceae. The Viscaceae is the family of mistletoes characteristic of the northern hemisphere. Some authorities include this family with the Loranthaceae which is the main southern hemisphere family, and the one best represented in Victoria.

Morphology

Both families have simple flowers of basically a single series of segments, although the Loranthaceae has a weakly developed calyx. The two families both have inferior ovaries, and, with few exceptions, berry-like fruits with sticky flesh surrounding the single seed. The main features that distinguish the two families are summarised in Table 1.

It almost goes without saying that all members of both families are parasitic (or more correctly hemiparasitic), but as the parasitic habit has arisen in many plant families (e.g. the snapdragon family, Scrophulariaceae, Orobanchaceae, the dodder families Lauraceae and Cuscutaceae, and the sandalwood family, Santalaceae), this trait alone cannot be considered a strongly uniting feature.

If the two families are recognised as being distinct, then Loranthaceae is regarded as the more primitive. One of the features that is regarded as primitive, relative to Viscaceae, is the presence of root-parasites in the family. In Australia, although only *Nuytsia*, the Western Australia Christmas tree, and *Atkinsonia*, a small shrub confined to the Blue Mountains of New South Wales, are root parasites, the common Creeping Mistletoe *Muellerina* is

interpreted as having a system of attachment that is somewhat intermediate between root parasitism and the single-point above-ground attachment, which is a feature of the more advanced genera such as *Amyema* or *Dendrophthoe*. Other characteristics that point to a more primitive origin include the larger, relatively complex inflorescences, and fine features of floral and stem anatomy.

Origins and Distribution

The Loranthaceae is generally regarded as having a Gondwanan origin. Its widespread occurrence in the southern continents of Africa, South America and Australia with associated islands, plus the occurrence of several small primitive, or so-called relictual genera, within the region is taken as evidence of this. The occurrence of Loranthaceae in areas beyond these, such as North America, southern Europe, and southern Asia, is assumed to be a consequence of invasion following contact of southern and northern landmasses through tectonic movement. Through a similar analysis of present-day distribution, the Viscaceae is believed (at least by some) to have arisen independently on the northern landmass, Laurasia, and then migrated southward into Australia after contact of the two supercontinents (Barlow 1983, 1984).

Although on the surface this appears to be a reasonable analysis, there are difficulties in justifying separate origins of the two families. One of two assumptions appear necessary to account for the above theory:

1. That the common ancestor of both families had evolved when the two supercontinents, Gondwana and Laurasia,were part of the same landmass,Pangea. The latest timing for this (i.e. before the division of Pangea into Gondwana and Laurasia) is approximately 200 million years ago (although estimates do differ), much earlier than most estimates for the origin of flowering plants (about 120 m.y.a.).

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or

2. That many of the similarities shown between the families are the result of convergent evolution of groups of independent origin (that is the acquirement of characteristics through similar life strategies), rather than through the common (recent) ancestry implied by phylogenies supported by most plant systematists.

Alternatively, if both families were of Gondwanan origin, then the Viscaceae might have evolved from the Loranthaceae (or a close, perhaps now extinct relative), or evolved later than the Loranthaceae from a common ancestral stock (e.g. the Olacaceae has been suggested). The present-day distributions of the families could be explained by dispersal after contact of Gondwana and Laurasia, with (for whatever reason) the Viscaceae having moved more strongly northwards than the Loranthaceae. This possible origin appears to avoid the difficulties raised by the more commonly espoused theory given above.

Whichever of these is true (and neither may be), it seems clear that the mistletoes as a lineage have been around for a long time!

Both groups probably evolved during a warmer, wetter phase of world weather. The relative newness of the Viscaceae in Australia is well supported by the family's present distribution. With just one exception (*Korthalsella leucothrix* of SA and WA) the family is entirely confined to the relatively warm, moist environments of forests of the east and northern coasts of Australia. In Victoria, the family is confined to east Gippsland, the region with the warmest and wettest conditions for plants; one species, Jointed Mistletoe *Korthalsella rubra* being confined to warm-temperate rainforest in this state.

Conversely, the Loranthaceae is widespread through humid to semi-arid and arid habitats in Victoria, Australia generally and also other countries - a reflection of the long period of time available to members of the family to invade new habitats.

It is interesting that the plant families commonly parasitized by Mistletoes (at least in Australia) are the Santalaceae, Proteaceae, Myrtaceae and Mimosaceae. Although not necessarily closely related, these families are nowadays generally regarded as belonging in the same evolutionary 'ball park' and were probably around (and may even have been prevalent) at the time of diversification of the mistletoe families. They may, therefore, represent an intimate association stretching back over 100 million years - an impressively long marriage by any standards.

It hardly needs to be emphasized that discussion on the evolution of the mistletoes (as with most other groups of living things) is necessarily conjecture, using clues given to us by today's members of the groups that are the expression of the twists and turns of the evolutionary process over barely imaginable periods of time.

Identification

For Victorians, the identification of mistletoes is relatively simple. The families are readily distinguished by their flowers - Loranthaceae have showy, usually brightly coloured flowers, and Viscaceae have

Table 1. Major features distinguishing Viscaceae from Loranthaceae (after Calder 1983).

Viscaceae	Loranthaceae
1. Inflorescence simple	1. Inflorescence often complex
2. Flowers minute, unisexual	2. Flowers large (at least 5 mm long), usually bisexual
3. Calyx absent	3. Calyx present (but often small)
4. Anthers opening by pores	4. Anthers opening by longitudinal slits
5. Pollen spherical	5. Pollen usually 3-lobed
6. Sticky layer of fruit usually within the vascular bundle	6. Sticky layer of fruit usually outside the vascular bundle
7. Large chromosomes with basic numbers of $x = 10, 11, 12, 13$ or 14	7. Medium to large chromosomes with a basic number of $x = 12$, reduced to $x = 8$ or 9 in most advanced members of family

small, dull flowers. If the plants are not in flower, their foliage gives them away. Jointed Mistletoe *Korthalsella rubra*, as the common name implies, is a bizarre, virtually leafless plant with flattened, jointed stems where the tiny flowers occur in small clusters at the joints. In Victoria, it occurs only on Lilly-pilly *Acmena smithii*. The fruits are small and weakly explosive. It has been suggested that the seeds are dispersed by transport on feathers and feet rather than by being eaten and then voided. Interestingly, its distribution in Victoria matches the natural distribution of the Grey-headed Flying-fox *Pteropus poliocephalus*. Perhaps in feeding on *Acmena* fruits the bats receive the shrapnel seed of 'exploded' *Korthalsella* fruits and effect mammalian rather than avian dispersion.

Golden Mistletoe *Notothixos subaureus* (Fig. 12) is readily identified by its covering of yellowish hairs, at least on the young growth. It is parasitic on other mistletoes of the family Loranthaceae, usually *Dendrophthoe* (e.g. Figs. 1, 2) and its fruits are fleshy berries like those of most other mistletoes. Both Jointed and Golden Mistletoes are confined to East Gippsland, eastward from the Snowy River. If you are not in East Gippsland, identification to family is even easier.

Members of the Loranthaceae are a little more difficult to identify, but with a little practice, in many cases involving observation of the host as much as the mistletoe, identification is relatively straightforward.

Muellerina (e.g. Figs. 4, 5) gives itself away by having a creeping rootstock, hence the common name of one species, the Creeping Mistletoe. All the other genera attach to the host by a single point, often inducing a swelling on the host's branch. The genus is named after Ferdinand von Mueller, one of the founder members and first Patron of the Field Naturalists Club of Victoria.

When in flower, members of the largest genus *Amyema* (e.g. Figs. 8-11) are readily distinguished in having petals that split to the base. In *Lysiana* (e.g. Fig. 3) and *Dendrophthoe*, the flower is tubular for at least half the length. Those two are readily distinguished vegetatively, the former having leaves opposite or in clusters, and the

latter having alternate leaves. Again, geography is perhaps the simplest method of identification, with *Dendrophthoe* being confined to East Gippsland (Mallacoota area), where it grows on *Eucalyptus* or close relatives *Angophora* and *Corymbia*, while *Lysiana* is conveniently absent from that part of the State and never occurs on eucalypts or their close relatives.

The following key should allow identification of the Victorian mistletoes, and is adapted from the treatment in Jeanes (*in press*).

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Jeanes, J.A. (*in press*). Loranthaceae. *In* ''Flora of Victoria' vol. 4.

All photographs courtesy M Calder, except Fig. 10, courtesy R. Fletcher.

Fig. 1. *Dendrophthoe vitellina* (F. Muell.) Tieghem.

A KEY TO VICTORIAN MISTLETOES (after Jeanes, *in press*)

1. Plants with relatively large (15 mm long or more), colourful flowers; stems not jointed or golden-pubescent (but sometimes with rusty scales); widespread (Loranthaceae) 2
1. Plants with small (under 3 mm long), dull flowers; stems golden-pubescent or jointed; East Gippsland only (Viscaceae) 12

2. Petals united to the middle or higher into a curved tube 3
2. Petals free to base or almost so 4

3. Petals 5; leaves mostly alternate or scattered; inflorescence raceme-like, consisting of single flowers (far East Gippsland) ....**Dendrophthoe vitellina** (Fig.1, 2)
3. Petals 6; leaves opposite or clustered; inflorescence usually 2-flowered .....**Lysiana exocarpi** (Fig.3)

4. Rootstock creeping, attached to host at various points; anthers dorsally attached to the filaments, versatile; inflorescence terminal (*Muellerina*) 5
4. Rootstock not creeping, attached to host at a single (often swollen) point; anthers basally attached to the filaments, immobile, introrse; inflorescence axillary (*Amyema*) 6

5. Leaves oblong to orbicular, usually less than 8 cm long, apex rounded, more or less penninerved; stems erect or spreading; anthers 1–1.5 mm long; host mostly *Banksia* or *Allocasuarina* ....**Muellerina celastroides** (Fig.5)
5. Leaves linear to lanceolate or oblong, usually more than 8 cm long, apex acute, more or less curvinerved; stems pendulous; anthers 2–2.5 mm long; host usually species of *Eucalyptus*, but also a wide range of cultivated trees.................................**Muellerina eucalyptoides** (Fig.4)

6. Leaves terete 7
6. Leaves flat 8

7. Inflorescence glabrous; leaves green, 2–6(–8) cm long; host plants *Acacia* and *Senna* ....**Amyema preissii** (Fig.6)
7. Inflorescence tomentose; leaves greyish, 6–12 cm long; host plants *Casuarina* or *Allocasuarina* ....**Amyema linophylla** (Fig.8)

8. Rays of inflorescence 2 (i.e. inflorescence forked near base) 9
8. Rays of inflorescence mostly 3–7 10

9. Flowers greenish, mature buds hairy; leaves greyish; host plants *Acacia* ....**Amyema quandang** (Fig.7)
9. Flowers crimson, mature buds glabrous or with few scattered hairs; leaves greenish; host plants commonly in Santalaceae or Loranthaceae ....**Amyema miraculosa** (Fig.9)

10. All flowers usually pedicellate; leaves often yellowish; host plants *Eucalyptus* (boxes) and *Acacia* ....**Amyema miquelii** (Fig. 11)
10. At least central flower(s) of triad or tetrad sessile; leaves usually green or grey-green 11

11. Leaves lanceolate, often curved, 10–25 cm long; corolla in mature bud tomentose; host plants *Eucalyptus* or *Acacia* ....**Amyema pendula** (Fig.10)
11. Leaves ovate, elliptic or broad-oblong, 4–10 cm long; corolla in mature bud glabrous or with few scattered hairs; host plants Santalaceae, Loranthaceae, Myoporaceae or Casuarinaceae ....**Amyema miraculosa** (Fig. 9)

12. Plant leafy, often golden yellow, usually growing on other mistletoes (often on *Dendrophthoe vitellina*); stems terete with flowers in terminal and/or axillary clusters ....**Notothixos subaureus** (Fig.12)
12. Plant with minute scale-like leaves, appearing leafless, dark green, growing on *Acmena smithii*; stems jointed, strongly flattened, with flowers almost sessile in joints ....**Korthalsella rubra** (Fig.13)

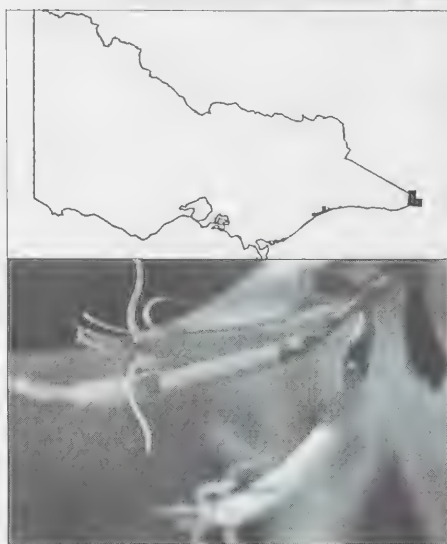## Distribution of Victorian Mistletoes (with photographs of species)
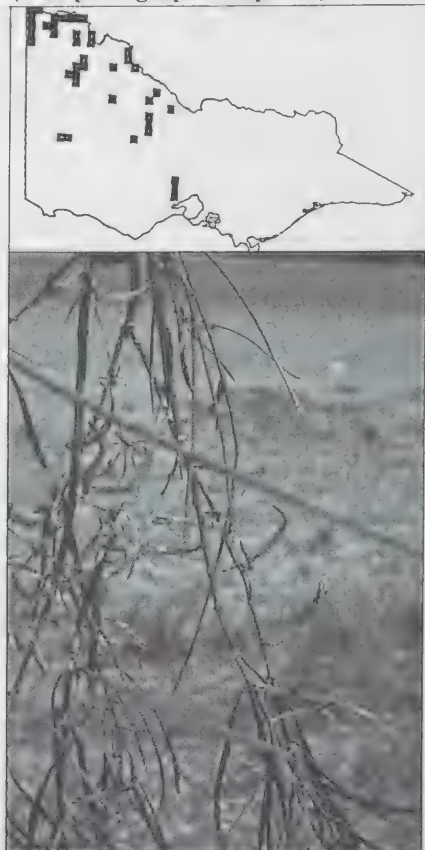

Fig 2. *Dendrophthoe vitellina.*

Fig 3. *Lysiana exocarpi* (Behr.) Tieghem.

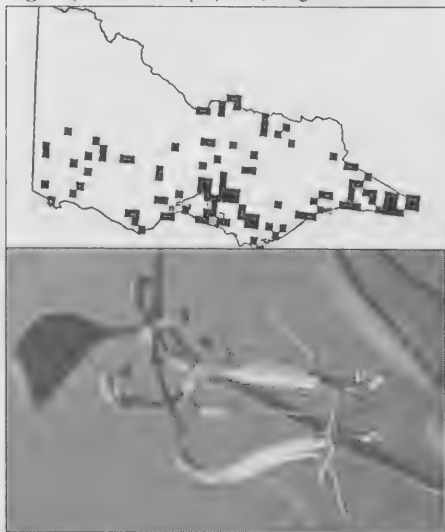Fig 5. *Muellerina celastroides* (Sieber ex Schultes & Schultes f) Tieghem.

Fig 4. *Muellerina eucalyptoides* (DC.) Barlow.

Fig 6. *Amyema preissii* (Miq.) Tieghem.

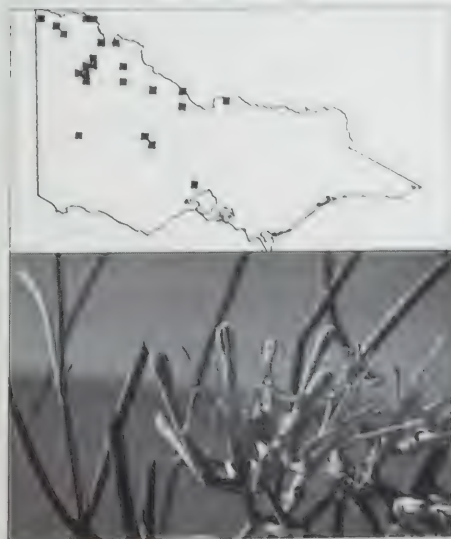Fig 7. *Amyema quandang* (Lindley) Tieghem flower and a seedling, two weeks old.
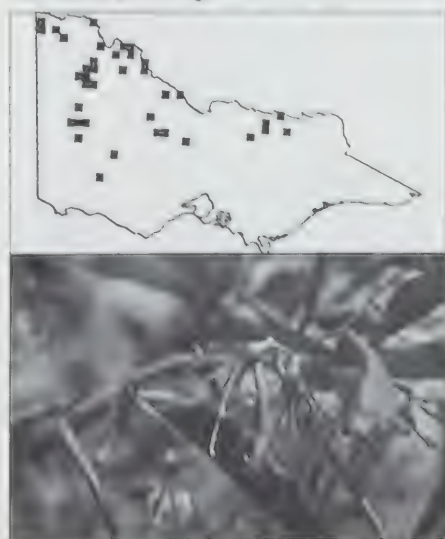

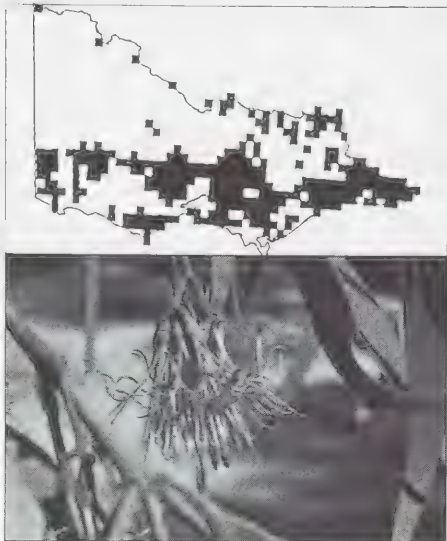Fig 8. *Amyema linophylla* (Fenzl) Tieghem.

Fig 9. *Amyema miraculosa* (Miq.) Tieghem.

Fig 10. *Amyema pendula* (Sieber ex Sprengel) Tieghem.

Fig 11. *Amyema miquelii* (Lehm. ex Miq.) Tieghem.

Fig 12. *Notothixos subaureus* Oliver.
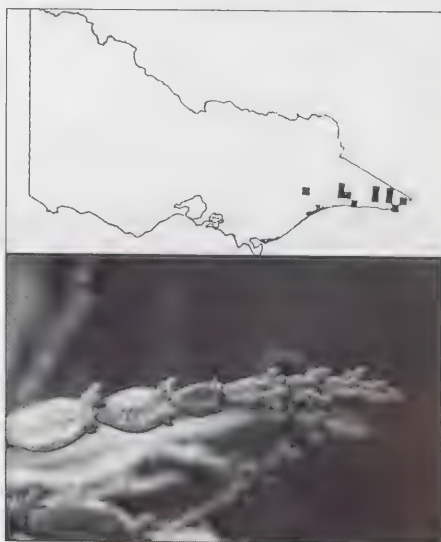
Fig 13. *Korthalsella rubra* (Tieghem) Engler.

The Influence of Host Attributes on Mistletoe Colonization: an Example from Mulligan's Flat Nature Reserve, ACT.

Paul O. Downey[1], A. Malcolm Gill[1] and John C. G. Banks[2]

Abstract
The study of host tree attributes at Mulligan's Flat Nature Reserve, in the Australian Capital Territory, showed that the incidence of Box Mistletoe *Amyema miquelii* colonizations on the dominant eucalypt species (approximately 20 to 25 m tall), *E. blakelyi* and *E. melliodora*, were similar. The height of the host trees and their canopy areas were significantly correlated with the basal area of their trunks (measured at 1.2 m from the ground). The number of mistletoes (density) per 10m^2 of canopy were positively correlated with the height of host trees. Larger host trees were more likely to carry mistletoes in higher numbers than smaller host trees. The numbers of dead mistletoe plants were correlated with the number of live ones. Host trees were not colonized until they reached a height of 3 m. Mistletoes which colonize smaller eucalypts (<7 m) are unlikely to persist to the time the host reaches 'maturity' or stand height. Plants of *Acacia dealbata* were free from mistletoe colonization in the study plots, despite comprising approximately 23% of the total plants surveyed.
(*The Victorian Naturalist* **114**, 1997, 105-111).

Introduction

Mistletoes are shrubby aerial hemi-parasites. They require water and inorganic nutrients from their host plants while meeting their own organic requirements through photosynthesis. They also depend on an effective dissemination mechanism and the ability of the host to provide structural support (Docters Van Leeuwen 1954; Kuijt 1969). The development of a haustorium enables the mistletoe to achieve both a physical and physiological bond with the host in the one structure. This close (cell to cell) relationship may influence the potential range of host species, or host specificity (Lamont 1982; Yan 1993). The host species may possess resistance mechanisms which prevent mistletoe establishment (Hoffmann *et al.* 1986; see Yan 1993). Once established, mistletoe infestations can reduce their host's growth rates (Nicholson 1955; Reid *et al.* 1994), and partially reduce the host canopy through the replacement of host foliage with mistletoe foliage (Kenneally 1973; Calder 1981) to the point of host mortality (Coleman 1949; Hawksworth 1983; Reid *et al.* 1994). Host death, however, has been attributed to other factors like drought in preference to mistletoe infestation (Hart 1961).

Studies on the effects of morphological

host attributes with respect to mistletoe colonization are scarce. Lamont and Southall (1982) found that trees of a similar age containing mistletoes were smaller than trees free of infestation, arguing that the extra water demand from mistletoes led to reduced host size. Hoffmann *et al.* (1986) noted that host size is a determining factor in mistletoe infestation. Reid (1991) and Sargent (1995) recognised that twig size was important for the germination and establishment of mistletoes. Thus morphological host attributes play an important role in mistletoe colonization.

This paper sets out to provide a preliminary study highlighting how host trees may play a role in mistletoe colonization and to investigate mistletoe colonization form the hosts perspective (from a snap shot in time). The hypotheses to be tested were: 1) The height of host species does not affect mistletoe colonization; 2) The number of mistletoes supported by a host tree is not proportional to the area of its canopy; and, 3) Mistletoe colonization is unaffected by host species.

Study site

More than 52% of the Australian Capital Territory (ACT) has been gazetted as either a National Park or a Nature Reserve (Lindenmayer 1992). However, only a few remnants of the original vegetation remain around Canberra. Of these Mulligan's Flat Nature Reserve (Fig. 1), the site of this study, comprises one of the largest and

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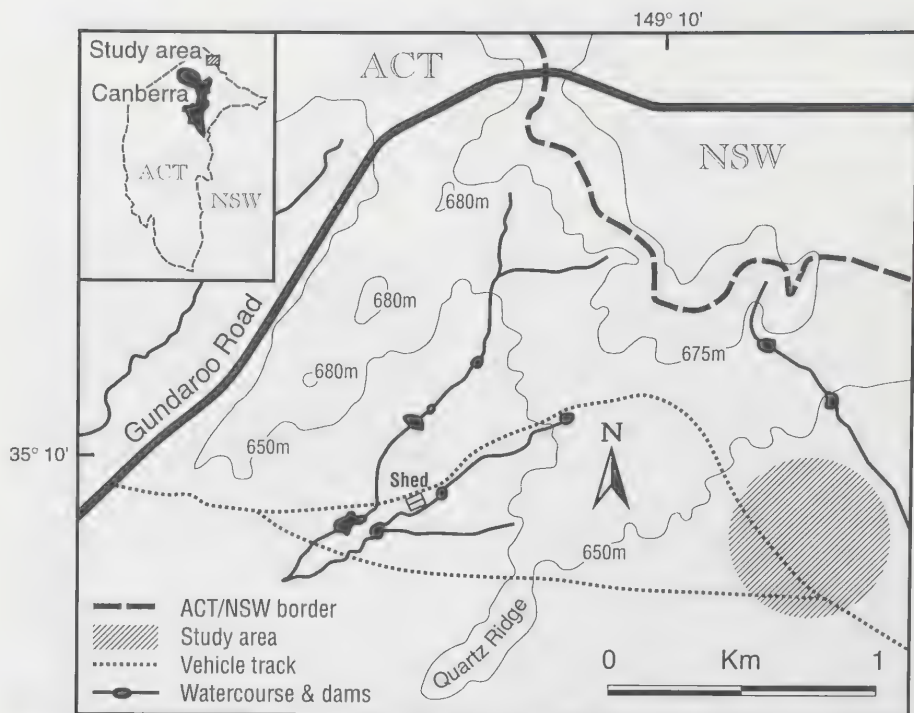[2] The Australian National University (ANU) Forestry Department Canberra, ACT 0200.

Fig. 1. Location of the study site in Mulligan's Flat Nature Reserve, ACT (after Lepschi 1993).

foremost examples of a lowland woodland and native grassland community (Frawley 1991; Lindenmayer 1992). Situated in the northern region of the ACT, it adjoins the NSW border, comprising an area of approximately 275 hectares. The site contains areas of cultural, historical and archaeological significance (NCDC 1988, 1989; Lindenmayer 1992) as well as several locally uncommon species of birds, mammals and plants. Sheep have grazed the area since the 1850s at low stocking rates (Lindenmayer 1992; Lepschi 1993).

In Australia there are eighty-eight species of mistletoes in the families Loranthaceae and Viscaceae (Barlow 1996). They vary greatly in the range and taxonomic diversity of hosts species they colonize. In the ACT and surrounding regions six species of mistletoe occur, none of which are endemic to the region (Burbidge and Gray 1970). Three viz. *Amyema cambagei, A. pendula* (formerly *A. pendulum* see Barlow 1991) and *Muellerina eucalyptoides* occur throughout most of South-eastern Australia. The fourth, *Notothixos cornifolius*, is at the

southern extent of its range, and the fifth, *Amyema miquelii*, covers the entire continent (Barlow 1984a; Downey *unpubl. data*). The sixth, *Muellerina bidwillii*, is known only from one collection (Burbidge and Gray 1970). Mulligan's Flat Nature Reserve is wooded by eucalypts which support two Loranthaceous mistletoe species, *Amyema miquelii* and *A. pendula* subsp. *pendula* (Lepschi 1993).

Methods

Seven quadrats of 50 metres x 50 metres were marked out so as to include the largest number of 'mature' woodland eucalypts possible in an area infested by mistletoes. These quadrats also included a range of shorter eucalypts as well as many plants of Silver Wattle *Acacia dealbata*. Quadrats were sampled during March and April 1996. All eucalypt species were measured and recorded for: species; height (heights were measured using a measured reference stick); number of live mistletoes per tree; number of dead mistletoes per tree; circumference over bark at 1.2 m to give a basal area (BA); and, two diameters of the

canopy at right angles to give an estimate of canopy area (canopy area provided a simple and relatively accurate way to quantify the canopy size). The mistletoe measurements recorded were: species; height of the lowest and the highest plant (at the haustorium); reproductive status (reproductive or not); and an estimation of size (arbitrary categories eg. small, medium etc.). All *A. dealbata* plants were counted, if they contained mistletoes, all the above measurements were recorded. However, if they were free from mistletoe infestation; they were simply categorised into three arbitrary height classes viz. small, medium and large.

Results

The hosts - The major tree species were Blakely's Red Gum *Eucalyptus blakelyi*, and Yellow Box *E. melliodora*, comprising 75.6% of the trees sampled. The other eucalypts present were Red Box *E. polyanthemos*, and Brittle Gum *E. mannifera*. There were 545 eucalypts in the survey and 159 Silver Wattles (which were mostly small trees or shrubs). There were approximately 100 woody plants per quadrat. The distribution of eucalypt heights was skewed by the large number of small trees (along the top of Fig. 2). The dominant trees ranged in height from 20-25 m, with the tallest tree measured being 35 m. Most of the smaller eucalypts were *E. blakelyi*, while the taller ones were mostly *E. melliodora* (Fig. 2). These two eucalypts were the only host species recorded for *A. miquelii* from the trees sampled. However, within close proximity of the quadrats *A. miquelii* was observed growing on three other eucalypt species and an Acacia viz. *E. mannifera*, *E. macrorrhyncha*, *E. bridgesiana* and *Acacia dealbata*.

Host attributes - Tree height was positively correlated with canopy area ($r^2=0.507$, $p<0.01$), and with basal area, BA ($r^2=0.593$, $p<0.01$). The canopy area was also positively correlated with BA ($r^2=0.921$, $p<0.01$).

Both eucalypt host species were similar with regard to their attributes, thus the data were pooled. The proportion of eucalypts supporting mistletoes increased with an increase in tree height (Fig. 3) in a statistically significant way ($r^2=0.798$, $p<0.01$).

Fig. 2. The proportion of eucalypt species in different height classes. Height class intervals are not all equal. The number above each column represents the number of eucalypts in each height class.
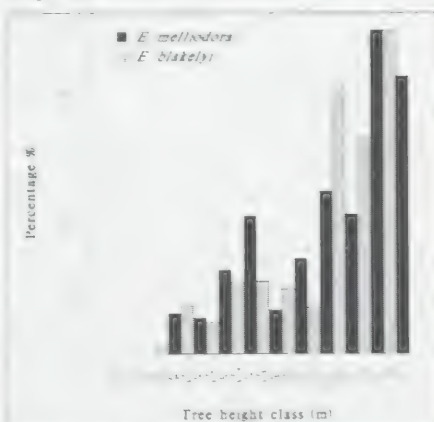

Fig. 3. The percentage (%) of trees which contain living mistletoes as a function of eucalypt tree height. Height class intervals are not all equal.

This was independent of the host species (Fig. 3). The number of live mistletoes ranged from one to fifty-one plants on a single host, whereas dead mistletoe numbers ranged from one to twenty. There were dead mistletoes beneath many of the host trees. The numbers of dead mistletoes per host plant were correlated with the number of live ones ($r^2=0.619$,
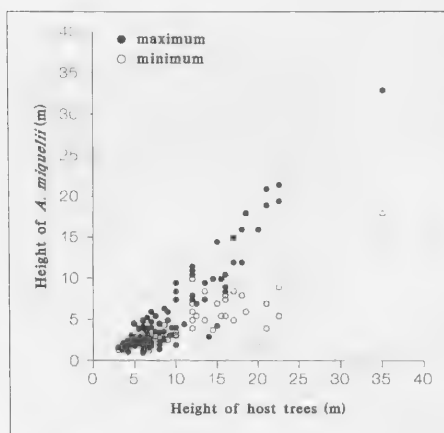
Fig. 4. Maximum and the minimum heights of mistletoe plants in each tree.

$p<0.01$). Host height was a significant factor in determining the number of mistletoe plants ($r^2=0.291$, $p<0.01$) in each tree. There was no mistletoe plant (dead or alive) on host trees under 3 m in height, despite the fact that these trees comprised 22% of the eucalypts sampled.

The minimum and maximum height at which mistletoes were attached in eucalypt canopies showed a wide vertical range (Fig. 4). The maximum height of mistletoes on their hosts was correlated with the maximum host height ($r^2=0.853$, $p<0.01$). The minimum mistletoe height was less strongly correlated with the host tree height ($r^2=0.610$, $p<0.01$).

It is possible that mistletoe colonization rate is a function of unit canopy area rather than a function of tree height or size. The number of mistletoes per unit canopy area (10 m^2) for trees of particular height classes class, y, were related to the mean height of each height class, x ($r^2=0.705$, $p<0.01$) by $y=1.111(1-e^{-0.126 \cdot (x-2.5)})$.

Mistletoes - There were four hundred and sixty-nine living mistletoe plants and one hundred and fifteen dead mistletoe plants surveyed. One hundred and seven eucalypts supported mistletoes. Thirty-seven supported both live and dead mistletoe plants, sixty-five supported only live mistletoes, and five supported only dead plants. Most of the small eucalypts (<10 m) supported live plants only. Mistletoe plants ranged in size from very small with only a few leaves to very large plants up to

about 3-4 m in length. Mistletoe plants on short eucalypts (<7 m) were mostly small in size and non reproductive. The maximum size of mistletoe plants increased with host height. Most larger plants were reproductive, unless senescent.

Discussion

The large number of small eucalypt plants present in the area (Frawley 1991; Lindenmayer 1992; Lepschi 1993) may be attributed to several historical factors including minimal disturbance from agricultural practices, minimal tree clearing, low stocking rates, a wildfire in 1979 (see Lindenmayer 1992) and recently the abolition of grazing pressures with the formation of the nature reserve. The regeneration was dominated by *E. blakelyi* (Fig. 2) perhaps due to a relatively high seed production in this species, or as a result of better establishment rates.

Host attributes - There were no mistletoes on eucalypts under 3 m tall. This may simply be the result of behavioural actions by the disseminators within a host (Atsatt 1979; Minko and Fagg 1989; Turner 1991; Norton *et al.* 1995) or that small twigs containing mistletoe seeds (on short plants, in our case) died more frequently than ones without mistletoes seeds (Sargent 1995). Sargent suggested that developing mistletoe seeds may induce death upon small twigs, preventing the establishment of mistletoes upon shorter trees. It simply may be that small trees do not provide adequate resources to entice disseminators to them. However, an individual of *A. miquelii* observed growing on a 1.6 m high *E. blakelyi* outside the study area suggested that colonization of short plants of this species is possible, but rare. This eucalypt had no more than 15 small grey-green leaves; the mistletoe had almost totally replaced the eucalypt's canopy. Patton (1917) noted that mistletoes were not observed on saplings, or half grown *Eucalyptus regnans*, which are tall plants by usual standards.

Above 3 m, the incidence of eucalypts supporting *A. miquelii* increased with tree height (Fig. 3). A similar observation was made by Norton *et al.* (1995), Lamont and Southall (1982) and Hoffmann *et al.* (1986). As age was not measured, size has been used as an indication of the tree age.

Roth (1974) found a higher frequency of Dwarf Mistletoes on younger (shorter) trees (*Pinus* spp.) than on older (taller) ones. However, it has been suggested that the age of host trees has no affect on mistletoe colonization (May 1941; Minko and Fagg 1989), with the exception of very young host trees (Salle *et al.* 1987).

The increasing maximum heights at which mistletoes were found as host height increased (Fig. 4) showed that host trees were being continually colonized. The increased density of mistletoes per unit of canopy area with respect to increased tree size also indicated this (density is expressed as the number of mistletoes per unit area of canopy). Most of the trees which supported live mistletoes also supported dead plants, the numbers of which increased with tree height. These observations indicate that the mistletoe-host relationship is a dynamic one. The hypothesis that the height of host species does not affect mistletoe colonization is rejected. The spatial positioning of mistletoes within their host canopies needs further investigation in relation to their future colonization of nearby host species or within the same host tree.

The mature trees, (stand height 15 m +) have been present for a longer period of time than younger trees (below 15 m) in the study site. As a result they may have had a longer exposure to mistletoe colonization. However, as there is no data about the length of time this particular mistletoe infestation has been in the study area, the present study can only investigate a snap shot in time.

Minko and Fagg (1989) found the oldest live mistletoe (*A. miquelii*) in their study area in northern Victoria to be twenty-nine years, while dead mistletoes averaged sixteen years, representing a natural attrition rate of between 6 and 8 % per year. Other authors suggest a longevity of decades (Calder 1981; Barlow 1981). The growth rings from a branch of *E. polyanthemos* supporting a mistletoe in Canberra implied an age of about sixty years (A.M. Gill and J.C.G. Banks *unpubl. data*). Eucalypts can live much longer, up to several hundred years. Mistletoes may just die of old age and be replaced by new plants on the same host (Kenneally 1973; Minko and Fagg 1989; Turner 1991). Kenneally (1973)

found that eucalypt trees which supported both live and dead mistletoes had a significantly greater number of mistletoes than trees which supported only live mistletoes.

Small trees only supported small to medium sized mistletoe plants, which where often non-reproductive, suggesting that they may be founder cohorts. Atsatt (1979) stated 'that once a compatible parasite-host combination occurs, the safest site for the progeny of that mistletoe will be other branches of the same individual'. The premature death of these individuals may arise from the senescence of the host's branches or by increased shade from the developing canopy of the host.

Mistletoe numbers not only increased with canopy area per plant, they also increased per unit area of canopy as tree height increased. Reid *et al.* (1992) also found that the number of mistletoes per host plant were significantly correlated with the volume of the host canopy. An increased canopy area may provide more opportunities for mistletoe colonization through a greater number of small twigs for colonization, increased protection for disseminators, and potentially greater structural support through increased 'strength' of the host, enabling mistletoe plants to reach a greater size. It can therefore be said that the persistence and size of the host canopy influences the number of mistletoe plants present at any one time.

Both dominant eucalypt species in this study had a similar level of mistletoe colonization (Fig. 3). However, all other tree species surveyed were potential hosts, but were free from colonization in the study area. The level of infestation of these other species outside the study area was very low. Within eucalypts high mistletoe infestation appears to be associated with smooth barked species (May 1941; Minko and Fagg 1989). The establishment rate of *A. miquelii* in the ACT from the 1950s to 1968 showed that the establishment rate was low, but was greater on faster growing tree species (Turner 1991). The hypothesis that host tree species had no affect on mistletoe colonization is accepted with caution as the opportunity for comparison with other host species in the study area was limited.

Historical factors may play a key role in mistletoe demography. A wildfire burnt

most of the area in 1979 but the effect this had on the mistletoe population is unknown. Mistletoe numbers could have been reduced, however, given the apparent sensitivity of these plants to fire (Gill 1996). Any effect would be expected to be greater on smaller plants than taller ones and those located low in canopies rather than near the tops of trees. Other observers have also noted the possible impact of fire on mistletoe populations, including May (1941), Coleman (1949), Hartigan (1960), Greenham and Brown (1957), Turner (1991) and Gill and Moore (1993). The effects of fire on mistletoe species needs further study.

Disturbance such as grazing by livestock is likely to degrade a woodland, the compound effects of which may lead to reduced mistletoe establishment and survival (see Norton *et al.* 1995). The structure of the open woodland may in itself be partly responsible for increased densities of mistletoes, as mistletoe infestations may be greater in open communities than closed ones (Blakely 1922; Coleman 1949). However in these communities there are fewer trees for mistletoes to colonize, thus the misguided impression may be formed that mistletoe numbers are increasing (Allen 1983). Mistletoes numbers at Mulligan's Flat are comparably higher than those reported in other studies (see Turner 1991; Norton *et al.* 1995).

The status of native grasslands in Australia have come under considerable attention in recent years, being the most endangered and degraded of our ecosystems (see Kirkpatrick 1995; Frawley 1991). Human disturbance through grazing, tree clearing and changed fire regimes have contributed to their demise (Kirkpatrick 1995). Other factors like invasion of woody weeds and the encroachment of tree species can also influence the status of these ecosystems. In the ACT and surrounding regions modified open woodlands/grasslands are susceptible to heavy infestations by mistletoe species as evident by the high numbers of mistletoes present at Mulligan's Flat and Cooleman Ridge in the southern ACT (A.M. Gill *unpubl. data*). However, practical control of existing mistletoe infestations is difficult (Hartigan 1971; Minko and Fagg 1989;

Gill and Moore 1993).

An important factor to consider in regards to mistletoe colonization is the rate at which mistletoe populations spread. Keast (1958) determined the maximum dispersal distance of the mistletoebird to be metres rather than kilometres, but this distance has not been studied further. The rate of spread of Dwarf Mistletoe in North America was 30-50 cm per year, although this is a self dispersing species (Hawksworth 1961). The rate of spread of bird dispersed mistletoe needs to be addressed, especially with respect to mistletoe colonization.

The present study provides a snap shot in time of mistletoe colonization. Without comprehensive data about individual trees and mistletoe plants over many years, colonizations rates could not be established. The establishment of colonization rate would however lead to a better understanding of mistletoe colonization and the role hosts plants may play.

Conclusion

Host attributes can influence mistletoe colonization. The host attributes examined were: tree height; canopy area; and, tree species. Of these the height of the host tree and the host canopy area had the greatest influence on mistletoe numbers. The shorter eucalypts possessed smaller canopy areas and lower mistletoe densities per unit of canopy area. There was no mistletoe on trees under 3 m in height. Mistletoe colonization was unaffected by eucalypt host species, as the dominant species *E. blakelyi* and *E. melliodora* were colonized to similar levels.

An in-depth study of the effects mistletoes have on their host tree species is long over due, as is the study of the rate of spread of mistletoe colonization. The effects of fire on mistletoe populations also needs to be addressed.

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Mistletoe in Forest Management in Victoria

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Abstract

A recent survey in Victorian forest areas has confirmed that mistletoe occurrence is widespread and that infestation is most noticeable in the box-ironbark forest type. A total of 27 eucalypt species were found to be hosts to mistletoes (mainly Drooping Mistletoe and Box Mistletoe), while 7 species were identified as not generally susceptible. Bark type did not seem to be a factor determining susceptibility. Survey respondents indicated that up to 70-80% of box and ironbark eucalypts supported mistletoes in severely infested areas.Research in NSW has shown that heavy mistletoe infestation can significantly reduce eucalypt growth rates as well as lead to tree mortality.Following major, but largely ineffective efforts in the 1920s and 1930s to either prune off mistletoe or to thin out badly-infested trees, current control operations in State forests are mainly confined to occasional removal of infested trees during commercial thinning for firewood and fence posts. (*The Victorian Naturalist* **114**, 1997, 112-115).

Introduction

Infestation of forest trees by mistletoe plants has been recorded by Victorian foresters since at least 1920.

This paper reports the results of a recent survey of the distribution and impact of mistletoe in a number of Victorian forest areas, and discusses past and present techniques used to control heavy infestations. The term 'mistletoe' in this paper primarily refers to Drooping Mistletoe *Amyema pendula* and Box Mistletoe *A. miquelii*.

Extent of Mistletoe in State Forests and Reserve.

In July 1996, a survey form was sent out to the Senior Foresters in Victoria's 15 Forest Management Areas requesting information on localities affected, rate of spread, eucalypt species affected, impact on infested trees, and control methods used. Their responses, though not comprehensive, together with the author's own observations, were used to compile Table 1. Areas which have light and scattered occurrences are not given in Table 1.

Eucalypt species infested with mistletoe.

The survey results indicated that a wide range of species acted as hosts for mistletoe plants. In addition, field naturalists Ron Hateley (Clunes), and James Turner (Kalimna), provided additional species. My own observations, reports from Forests Commission Annual Reports and species listed in Minko and Fagg (1989) extended the original list. The compiled list is given in Table 2 - for eucalypts only but no claim

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is made that it is exhaustive. Unfortunately, the sources of data do not allow detail to be given regarding differences in infestation levels by species, but this is known to vary widely, depending on the locality and other factors (see below). Mistletoe-induced mortality is not common is any species. However, it is clear that the box-ironbark forest type in Central Victoria is most heavily affected in Victoria, as also noted by Calder (1981). Fig. 1 shows mistletoes on a River Red Gum near the Goulburn River at Shepparton North.

Table 2 shows that the Box, Red Gum, and Ironbark groups, which are all in the Symphyomyrtus sub-genus (Pryor and Johnson 1971) seem to be far more often infested than the Stringybarks, Peppermints, and Ash group (Monocalyptus). The reason for this could be that the Symphyomyrtus group simply prefers the drier and more open sites, which are also favoured by the Mistletoe Bird. Both sub-genera include species which have rough and smooth bark on the upper branches, so that bark type does not seem to be a factor which affects susceptibility.

Although my research has been limited, a number of important forest eucalypts (of both sub-genera) have **not** been reported as having had mistletoe infestation. These include: *Eucalyptus fastigata;E. consideniana; E. cypellocarpa; E. pauciflora; E. sieberi; E. dalrympleana,* and *E. mannifera.*

Status of mistletoe infestations

Of a total of 24 comments on mistletoe 'Status', 11 indicated 'spreading', 13 said 'static', and 0 indicated 'declining'. These comments related to both large and small areas of forest.

Table 1.. Some forest areas moderately to severely affected by mistletoe in Victoria.
Key: S.F. - State Forest; N.P. - National Park, R.P. - Regional Park, S.P. - State Park.

Region	Localities
North-eastern Victoria	Killawarra S.F., Moyhu, Carboor, Chiltern R.P., Goulburn River forests (Echuca to Murchison).
Gippsland	Mt Taylor S.F., Snowy River N.P. (Deddick), Stockdale S.F, Dargo S.F. (Hibernia), Warrandyte S.P., Woori Yallock Moondarra S.P.
Western Victoria	Bendigo, Rushworth, Sandon S.F., Wail S.F., Maryborough, Dunolly, Murray River forests (Robinvale to SA border), Clunes S.F., You Yangs R.P., Long Forest Flora and Fauna Reserve.

In the Robinvale area, mistletoe was reported as spreading in the Black Box *E. largiflorens* area, but static in the River Red Gum *E. camaldulensis* areas.

Frequency of infested trees

The survey results showed that, as expected, the degree or frequency of infestation varied with host species and the locality.

In many areas, e.g. the Wombat State Forest - a Messmate-Gum-Peppermint forest, the frequency of trees with at least one mistletoe was 1-2%, but 80-90% was not uncommon in parts of the box-ironbark forests. For example, Sandon State Forest had 80-90% on *E. leucoxylon*, *E. melliodora* and *E. sideroxylon*. In Clunes State Forest mistletoes occurred on 70-80% of *E. leucoxylon*, 30-50% of *E. melliodora*, *E. microcarpa*, *E. tricarpa*, *E. macrorhyncha*, and *E. polyanthemos*, and 0% on *E. obliqua* and *E. baxteri*. (Hateley, 1996, *pers. comm.* 16 August).

In a roadside area next to the Heyfield log checking station, 24% of Red Box *E. polyanthemos* trees were infested with Drooping Mistletoe, and 43% of Red

Table 2. Victorian eucalypt species known to be susceptible to mistletoe infestation.

Monocalyptus sub-genus	
E. baxteri	E. delegatensis
E. dives	E. globoidea
E. macrorhyncha	E. muelleriana
E. obliqua	E. radiata
E. regnans	

Symphyomyrtus sub-genus	
E. albens	E. bauerana
E. blakelyi	E. bosistoana
E. bridgesiana	E. denticulata
E. globulus subsp. bicostata	E. goniocalyx
E. largiflorens	E. leucoxylon
E. melliodora	E. microcarpa
E. ovata	E. polyanthemos
E. rubida	E. sideroxylon
E. tricarpa	E. viminalis

Ironbark *E. sideroxylon* were infested with Box Mistletoe.

Impact of Mistletoe on Trees
Survey results

All locations with moderate to severe mistletoe frequency, reported tree crown dieback and or tree mortality. Tree death generally occurred when the mistletoe formed the majority of the crown biomass, although often trees survived for many years before they succumbed.

Dieback and death almost always occurred in large, old trees; infested regrowth was not usually visibly affected. It was reported that, along the Goulburn River, 5-6 mistletoes on a River Red Gum tree would eventually lead to its death (K. Lyle 1996, *pers. comm.* 5 August).

Experimental results

Recent research by Reid *et al* (1994) has confirmed that *A. miquelii* is injurious to the health of farm eucalypts in temperate Australia. This trial, which examined infested and disinfested *E. blakelyi* and *E. melliodora* trees on farms in northern NSW showed that over 33 months, 24% of heavily infested *E. blakelyi* trees died. In addition, the average increase in radial stem growth attributed to mistletoe removal was 55% for the *E. blakelyi* and 49% for the *E. melliodora*. In the control trees, diameter increment was negatively related to mistletoe infestation level. For *E. blakelyi*, on average, a tree with 50% of its crown being mistletoe, had a diameter increment of about half that of an uninfested tree.

These results support those of Nicholson (1955) who compared the radial growth of *E. polyanthemos* with and without infestation by *A. miquelii*.

Management of Mistletoe in Forest Areas

There are three main approaches which have been, or are, used to reduce the frequency of mistletoe infested trees in State forests - pruning, herbicide application and thinning. Only patches of severe infestation are considered for treatment and even then, funding priorities mean that little direct control work has been carried out in recent years. Hot fires will wipe-out mistletoes, but this is not a deliberately used technique!

It is recognised by the Forests Service that mistletoes are native species which are also habitat and food sources for a number of faunal species; as such, eradication is not an objective in any control operation.

Pruning

Pruning of branches carrying mistletoe clumps is a control technique which has been used sporadically in State forests at least since 1920 when it was reported that 'this parasite appears to be on the increase' (FCV, 1920). It was reported that 4,000 ha had been treated in 1936-37 (FCV, 1937). In the past, long-handled saws and ladders were used for pruning, being replaced in more recent times by chain-saws operated by men in 'cherry-picker' buckets, or by a chain-saw chain attached to a rope.

The survey results revealed that, in recent decades, mistletoe has been treated by pruning in the Wail, Rushworth, Dunolly and Killawarra State Forests (1960s), Chiltern Regional Park (1970s), Redcliffs (1980s) and Castlemaine district (1990s). These operations have been on a relatively small scale.

Pruning needs to be repeated at frequent intervals to maintain low levels of infestation. Although it is immediately effective, pruning is costly, it may miss high or small mistletoes, and it usually results in some loss of the tree's foliage which temporarily reduces growth.

Herbicide application

The stem injection control method involves injecting a solution of herbicide into the sapwood near the base of an infested tree. The herbicide is diluted to a specified level so that some of the mistletoe dies but the host tree survives.

Although it is cheaper than pruning, this method has only been used experimentally in State forests, due to the possibility of killing some trees. Treloar (1953) used 2,

4-D to treat infested *E. microcarpa* at Maryborough, based on research by Greenham *et al.* (1951). Minko and Fagg (1989) tested the injection procedure in north-eastern Victoria on eleven different eucalypt species with variable results, depending on season, host species, and type of herbicide. Although they found that trees less than 30 cm diameter should not be treated with this method, they were able to give recommendations for treatment.

The injection method using both glyphosate and triclopyr was tried at Murrindal on a number of severely infested *E. melliodora* trees but only gave a minor reduction in mistletoe numbers. At Euroa, a glyphosphate injection of several *E. blakelyi* had little effect on the mistletoe but the host trees remained healthy.

Direct spraying of mistletoe can be quite effective. For example, glyphosate sprayed directly on to mistletoe on *E. camaldulensis* at Little River gave good control, and 2, 4-D amine (0.5%) was used successfully on mistletoes in New South Wales (Hartigan 1971).

Thinning

Mistletoe removal by harvesting heavily infested trees has been (FCV, 1920), and still is, a widely-used control method, mainly in the box-ironbark and red gum forest areas.

Where commercial thinning operations (for posts, firewood, etc.) are carried out in regrowth, unhealthy, small and misshapen trees are marked for removal. Given that mistletoe infestation is regarded as one factor affecting the health of a tree, often trees which are infested are harvested. Trees need to have at least two mistletoes to be considered 'unhealthy'. However, infested Yellow Box *E. melliodora* trees are not harvested (unless dying) because of the value of this species to apiarists.

Discussion

Mistletoes occur on eucalypts throughout a large area of Victoria's forests, but only in relatively small areas are they frequent enough to cause problems to forest productivity.

Problem infestations generally seem to be in forests with a sparse canopy cover, such as the box-ironbark type and old, 'overmature' patches of mountain species such as *E. regnans*, and *E. denticulata* in East

Gippsland. Once established in an area, the mistletoe appears to survive for decades - unless a wildfire burns the forest. For example, the extensive 1985 Maryborough fire killed all the mistletoe in the box-iron-bark areas, which remained relatively free of mistletoe for about a decade (Hateley. R, 1996, *pers. comm.* 16 August). Most of the eucalypts, of course, recovered via epicormic shoots or coppice. This 'sanitising' effect of fire on mistletoe has been used to control Dwarf Mistletoes (*Arceuthobium spp.*) in North American conifer forests (Alexander and Hawksworth 1975).

Possible reasons for the apparent increase in mistletoe infestations in some parts of the State include:

- the general ageing of forests and trees, particularly in the box-ironbark areas, which allows more light into the canopy, possibly favouring the Mistletoe Bird and pollinating birds
- reduced numbers of hot fires in forests and farmland
- increased stress on trees from competition for moisture, insect/fungal attack, or soil compaction.
- minimal mistletoe removal work.

There appear to be few species of Victorian eucalypts which are not susceptible to the mistletoe, but the frequency with which a species is infested varies significantly, depending on factors such as location and age.

Given that research has shown that mistletoe infestation results in reduced diameter growth rate, the non-removal of mistletoe is resulting in reduced wood volume (as well as mortality) of a proportion of trees in Victoria's forests, particularly in the box-ironbark forests. This has an economic impact which the selective cutting out of badly infested trees only partially addresses.

Acknowledgments

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Fig. 1. Mistletoe plants on a River Red Gum *Eucalyptus camaldulensis* at Thompson's Bend in the Goulburn River forests near Shepparton North, 1991. Photo: Keith Lyle.

Mistletoe Management
Yarra Valley Parklands Survey

Glen Jameson[1]

Abstract
'Tree Decline' is defined as the progressive decline in health and numbers of trees. It is currently one of the major Conservation issues across Australia and Mistletoe has been implicated in Tree Decline. However, it is not regarded as a major cause, but it may be significant on a local scale where there is a heavy incidence on host trees which may then become stressed under difficult environmental conditions such as drought. A survey of 1,346 trees within Yarra Valley Parklands revealed that 228 (16.9%) suffered some degree of Tree Decline, but that only four trees (0.29%) had an incidence of both Tree Decline and Mistletoe infestation. Currently, with information based on this Survey, Mistletoe is not a significant contributor to Tree Decline in Yarra Valley Parklands. A Questionnaire of Melbourne Parks and Waterways Environmental Practitioners revealed that there had not been any active management of Mistletoe in the Parks, although three Reservoir Parks expressed concern over levels of Mistletoe incidence. It also indicated a need for broader based biological information on the role and function of Mistletoes in terrestrial ecosystems. These results are included as a supplement. (*The Victorian Naturalist*, **114**,1997, 116-121).

Introduction

Tree Decline refers to the progressive decline in the health or numbers of trees (Wylie *et al.* 1992) and is currently one of the major conservation issues in Australia (Clarke *et al.* 1995). Mistletoes have been implicated in the cause of Dieback or Tree Decline (Wylie and Bevege 1980; Wylie *et al.* 1992; Minko and Fagg 1989; Hawksworth 1983) although they are not always cited as a major cause (Day 1980), or even a factor (Grose 1980). A large number of the Tree Decline studies have placed greater importance on the role of, and dynamics between, invertebrates and pasture grasses (Lansberg 1988; Landsberg *et al.* 1990; Heatwole and Lowman 1980), or relationships between invertebrate and avian populations (Clarke *et al.* 1995).

Mistletoes may be a factor in Tree Decline on a local basis although not over larger areas (Kile *et al.* 1980), but may become prominent in circumstances of environmental stress such as during droughts, or where heavy incidences of Mistletoe occur on host Trees (Heatwole and Lowman 1986). There is often a complex background to the incidence of Tree Decline and although trees heavily infected by Mistletoe may be killed directly by them, they probably, more often than not, die as a result of a combination of stresses, one of which is Mistletoe (Heatwole and Lowman 1986). Tree Decline also occurs in areas where there is no Mistletoe and its role as an agent of widespread Tree Decline can

be difficult to assess (Wylie *et al.* 1992).

Despite their abilities in cryptic mimicry of host plants (Calder and Bernhardt 1983), the more common Mistletoes (Drooping Mistletoe *Amyema pendula* and Grey Mistletoe *A. quandang*) are generally easy to observe growing on host trees. Some individual plants persist for up to 20 years on host trees which may strengthen the perception that they are increasing in numbers and responsible for Tree Decline, as has been reported (Reid 1996; Wylie *et al.* 1992). A survey questionnaire of rural properties in Queensland (Wylie *et al.* 1992) revealed a surprisingly high incidence of Mistletoe infection in association with dieback-affected species. Therefore, it must be regarded as an important contributing agent to tree disorder in Queensland.

Mistletoes are integral members of terrestrial ecosystems (Knutson 1983) despite being a minor vegetative component of such systems. Mistletoe's interdependent relationship with a range of organisms (Calder and Bernhardt 1983) suggests the possibility that Mistletoe may be able to play an 'indicator' role in the diversity and functional health of a particular ecosystem. The quantity of Mistletoe may be indicative of a range of environmental conditions such as the status of the fire regime, the population natural Mistletoe predators, the integrity of shrub understorey, land management practices, the degree of fragmentation of bushland remnants, and isolation of individual trees (Reid 1996). Fragmentation and isolation of bushland remnants

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may result in over-use of particular trees by Mistletoe Birds. Conversely the absence of Mistletoe may indicate lack of faunal corridors, or low floral and faunal diversity.

The Yarra Valley Parkland (YVP) Mistletoe Survey was conducted to investigate the abundance and distribution of Mistletoe in sections of the Park and to analyse the current situation for any discernible management problems related to Mistletoe. Mistletoe was not perceived as an environmental problem by YVP Conservation staff and consequently there had not been any previous management of Mistletoe in the Park. The Survey was important to verify whether this direction was an appropriate one. Of critical importance in the Survey was the investigation of the relationship between Mistletoe and Tree Decline. Tree Decline is currently of considerable concern to the Management of Yarra Valley Parklands.

The Melbourne Parks and Waterways Questionnaire, completed by environmental practitioners working within eight Parklands managed by MPW (now Parks Victoria), was designed to determine levels of awareness and knowledge of Mistletoe, the problems and management techniques, if any, used to manage Mistletoe.

YVP Survey Area

Yarra Valley Parklands extends along twenty-four kilometres of the Yarra River, Melbourne's primary faunal corridor, from Pound Bend in Warrandyte downstream to the Burke Road bridge in Ivanhoe. They include around 1,400 ha of bushlands, wetlands, orchards, former agricultural land and developed Parkland such as Birrarung, Banksia, Yarra Flats and Westerfolds. Yarra Valley Parklands are part of the open space network owned/managed by Parks Victoria which includes some 42 Parks throughout greater Melbourne covering 5,855 ha hosting some 6.1 million visitors per year.

The study area has a temperate climate, with January the hottest month of the year with a mean daily maximum of 27°C and July the coldest, mean daily maximum of 13°C. The average yearly rainfall at the nearest recording station (Doncaster) is approximately 760mm.(Bureau of Meteorology, 1968). The area surveyed, lies between 18 and 23 kilometres north-east of Melbourne.

The Mistletoe Survey covered areas along the terraces of the Yarra River and land sloping down to the Yarra River, between Templestowe and Warrandyte and was conducted between 15-25 of August 1996. The Yarra River terraces (sites 1, 2, 3 and 4) are of deposited Quaternary alluvium, supporting the vegetation communities Manna Gum Riparian Forest-Riverbanks (Cook 1996) Manna Gum Riparian-Riverbanks Terrace and Manna Gum Rocky Riparian Scrub (Beardsell 1996) covering 4.2 ha. Longridge (site 5) is steeper hillslopes composed of Silurian siltstones, supporting the vegetation community Valley Forest (Beardsell 1996) covering 14.5 ha. Candlebark (site 6) has undulating hills composed of Silurian sandstone supporting the vegetation community Long-leaf Box Yellow Box Woodland (Cook 1996) covering two hectares.

The condition of the vegetation ranged from:

- Remnant and revegetation in poor condition, generally less than 10 meters in width along the River (site 1);
- Isolated, remnant Trees remaining in paddocks of exotic pasture grass with Tree Decline a dominant feature (site 5);
- Good to moderate, comparatively intact (site 2);
- Moderate to good quality of Regional Significance (Beardsell 1996) (site 3);
- Moderate to good quality of Regionally Significant Vegetation in good condition (Cook 1996) (site 6);
- State and Regionally Significant vegetation (Beardsell 1996) in good condition (site 4).

All sites, except site 1 (which is managed by Manningham Council), are actively managed by Parks Victoria for pest plants and pest animals and are part of current and future revegetation projects.

Methodology
Site Selection

The Riverine sites 1, 2, 3 and 4 were surveyed during a Riverine Vegetation Assessment currently being undertaken at Yarra Valley Parklands. These sites were randomly selected and surveyed during the Riverine assessment.

Sites 5 and 6 were chosen because of the known incidence of Mistletoe within the sites and both offered different vegetation communities, geology and contrasting

Table 1. Mistletoe Survey, Yarra Valley Parklands. Result from the total number of properties surveyed showing the incidence of Tree Decline in the Yarra Valley Parklands.

Key: Species Potential tree species; **Tot**= total number of trees; **M't**= Total number of trees affected by mistletoe; *Am*= Amyema miquila, *Ap*= A. pendula, *Aq*= A. quandang; **Trees in Decline Severity Rating and Criteria** - **No** = number of trees having some degree of decline; **1**= Normal, healthy crowns, **2**= Slight dieback in crowns (0-30% reduction), **3**= Moderate dieback in crowns (30-60% reduction), **4**= Severe dieback in crowns (60-90% reduction), **5**= Dead; **M/D** = number of trees with both Mistletoe infection and some degree of tree decline.

Species	Tot	M't	Mistletoe Sp.			No	Trees in Decline Severity					M/D
			Am	Ap	Aq		1	2	3	4	5	
Eucalyptus viminalis	419	9	2	24		29	390	8	8	7	6	
Hill Manna aff *viminalis*	1				1		1					
E. meliodora	196	8		10 (+ 8 dead)		51	145	21	10	16	4	1(5) 1(2)
E. camaldulensis	22					5	17		2	3		
E. rubida	11					9	2	4	3	1	1	
E. goniocalyx	3	1		2		1	2	1				
E. ovata	6					5	1	4	1			
E. polyanthemos	95	5		10		28	67	21	2	4	1	1(2)
Acacia dealbata	405	16		4	68	62	343	16	12	15	19	1(5)
A. mearnsii	182	3				38	144	14	13	5	6	
A. implexa	3						3					
A .melanoxylon	3						3					
TOTALS	**1,346**	**42**	**2**	**59**	**68**	**228**	**1118**	**89**	**51**	**51**	**37**	**4**
Percentage						16.9	83.1	6.6	3.7	3.7	2.7	0.3

variation in integrity and condition of vegetation.

Tree Selection

All trees within the site boundaries that were regarded as being able to support a Mistletoe were surveyed. All Eucalypts were at least 20 cm diameter at breast height (DBH) and Acacias 15 cm DBH. If Mistletoes were dead (and impossible to identify) on host trees (which in this survey were all Yellow Box *Eucalyptus melliodora*), they were recorded as *Amyema pendula*. This was the most common Mistletoe and,therefore, the most likely species present.

Survey Table

The Survey Table (Table 1) illiustrates a representation of the range of Mistletoe host species with the number of Mistletoes observed upon them, and the record of the severity of Tree Decline suffered by the trees in the survey.

The severity ratings method used in the

Yarra Valley Parklands Tree Decline monitoring program has been adopted from a system formulated by Wylie *et al.* (1992) A Survey of Native Tree Dieback in Queensland. These ratings are found on page 13 of the source document.

In the Table, section **Total T.D.** means the total number of trees recorded as having some degree of Tree Decline. The column **M'toe and TD** represents the number of trees recorded with both Mistletoe and some degree of Tree Decline. Thus, **M'toe and TD** column is to be read as two trees with Mistletoe and Tree Decline with a severity rating of two.

Results

A total of 1,346 potential Mistletoe host trees were surveyed of which 42 were observed hosting Mistletoes (3.12% of total). There were 129 Mistletoes on the 42 trees, an average of just over three Mistletoes per infected tree, although the incidence upon *Acacia dealbata* was higher (72 Mistletoes on 16 Trees, an average

of 4.5 per host tree). There were a total of two Box Mistletoe *Amyema miquelli,* 59 Drooping Mistletoe *A. pendula,* and 68 Grey Mistletoe *A. quandang* recorded.

The distribution patterns of the Mistletoes varied with each site and the vegetation coverage. The Mistletoes tended to occur in groupings on trees in close proximity to one another in sites 1, 2 and 4. In site 1, all 18 Mistletoes were distributed within a 30 m radius of the western end of the site. In site 2, the Mistletoes were distributed in two distinct groups, one group of eight *Acacia dealbata* fifteen meters apart hosting 50 *Amyema quandang* and on five Manna Gum *Eucalyptus viminalis* within a thirty meter radius hosting 21 *Amyema pendula.* The two other host trees were nearby. In site 4, the two *Eucalyptus melliodora* hosting five *Amyema pendula* were beside each other.

Site 3 had a sparse and isolated distribution of Mistletoes. On site 5, all the trees were scattered and mainly isolated. Site 6 displayed a strong relationship with the five *E.melliodora* hosting five *A. pendula* in close proximity to the main dirt road - all occurrences within 15 meters of the track, although they were not grouped together in any discernible way. However, all three *Acacia mearnsii* trees hosting the seven *Amyema quandang* at this site were within a radius of 10 meters of each other.

Tree Decline affected 228 trees out of the total of 1,346, that is one tree out of every 5.8 surveyed or 16.9% (Table 3). Some 1,118 trees had no visible signs of Tree Decline (83.06% of total) , 89 (6.6%) had slight dieback in crowns (0-30% reduction), 51 (3.7%) had moderate dieback in crowns (30-60% reduction) and 51 (3.7%) severe dieback in crowns (60-90% reduction). A total of 37 (2.74%) Trees were recorded as prematurely dead due to Tree Decline.

The incidence of Mistletoe occurring on host Trees that also recorded some degree of Tree Decline was four trees out of the total of 1,346 (0.3%) trees surveyed, an incidence of one tree in every 336.5. There were two instances of tree deaths that coincided with hosting Mistletoes, although it was not possible to determine the cause of their death.

Discussion

Mistletoe is known to reduce the vigour and growth of trees (Reid *et al.* 1994) and

this may have been the case with Acacias in sites 1 and 2, which hosted large numbers of Mistletoes. However, generally in the survey, the incidence of Mistletoe was observed not to have a negative impact on the health of the tree hosts.

There were eight dead mistletoes on living host trees, all of which were *Eucalyptus melliodora.* This suggests that some species of host tree may have mechanisms to deal with Mistletoes.

Conclusion

In the sections of Yarra Valley Parklands surveyed, at present there appears to be no positive correlation between the incidence of trees hosting Mistletoe and the degree of Tree Decline. The analysis reinforces the perception of YVP Conservation Staff that Mistletoes do not constitute a threat to the functioning of the ecosystems within the Parklands, although Tree Decline remains a major conservation issue.

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Supplement

Melbourne Parks and Waterways Conservation Staff Questionnaire Introduction.

Introduction

In a telephone survey Environmental Rangers in eleven Melbourne Parks and Waterways managed Parks were asked about their perceptions, information bases and management practices regarding Mistletoe.

Questions asked:
1. What species of Mistletoe occur in your Park?
2. What species of tree hosts Mistletoe?
3. What is the distribution of Mistletoes associated with?
4. Is the incidence of Mistletoe a concern to the conservation management?
5. In which situations is Mistletoe a problem?
6. Do you actively manage Mistletoe?
7. In which situations would you actively manage Mistletoe?
8. Does Mistletoe benefit the ecosystem at your Parklands?

Results

Point Cook Coastal Parkland and the Dandenong Gardens Parklands reported no incidence of Mistletoes. Sugarloaf Reservioir Park did not have a botanical survey of their flora and, therefore, could not respond on botanical details. Four species of Mistletoe were recorded across the remaining Parks - *Amyema pendula, A. miquelii, A. quangdang* and *Muellerina eucalyptiodes*. They were hosted by 14 species of Eucalyptus (*E. radiata, E. cephalocarpa, E.melliodora, E. leucoxylon, E. camaldulensis, E. polyanthemos, E. goniocalyx, E. ovata, E. goniocalyx x viminalis, E. obliqua, E. dives, E. tricarpa, E.pryoriana* and *E. viminalis*) and three species of Acacia (*A. dealbata, A. melanoxylon* and *A.mearnsii*).

Information on the identification and distribution of Mistletoes came principally from botanical surveys previously carried out within the Park systems where they existed. Environmental practitioners did not have a great deal of anecdotal information on Mistletoes regarding their distribution and ecological roles. This is not surprising considering the relative little focus that has generally been given to Mistletoes in general literature and environmental forums over the past decade.

Concern of park staff regarding the possible negative affects of Mistletoes on host trees came strongest from three Reservoir Parks - Cardinia, Sugarloaf and Upper Yarra. Independently, park staff from all three were concerned over the incidence of heavy Mistletoe coverage of host trees. Concern at Sugarloaf Reservoir Park centred upon several Red Ironbarks *Eucalyptus tricarpa* situated in well-used picnic areas that had almost 50% foliage coverage by Mistletoe (Andreas Seyffer *pers. comm.*). The loss of these shade trees would greatly reduce visitor amenity. A similar situation occurred with *E. radiata* Narrow-leaf Peppermints occurred at the Upper Yarra Reservoir Park. Concern about Mistletoe was most strongly expressed for Cardinia Reservoir Park where it was perceived as a problem in most areas of the Park.

Discussion

Although there was no research data available on the abundance and distribution of Mistletoe along the entrance road to the Cardinia Reservoir Park and the road to the Park Depot, observations on the degree of incidence of Mistletoe on host trees, suggest

that appropriate management may be in order. Many of the Trees along these two roads had over 20% Mistletoe foliage coverage and some were well in excess of this. Heavier incidence of Mistletoe occurrence appeared to be strongly related to the roadsides and forest edges of the park, although there are no doubt other factors such as the status of Mistletoe predator populations, would be involved. Integrated management planning and monitoring will be needed to resolve the Mistletoe problem.

General recommendations regarding the acceptable level of Mistletoe coverage range from 20% of total foliage (Malcom Calder *pers. comm.*) to Department Of Natural Resources And Environment pamphlet on Mistletoe stating that 'infestations of greater than 30% of the tree crown cause a significant decline in the growth of the host' (DCE, now DNRE, 1991). Loss of Trees along these routes, which may happen during events of environmental stress may detract from the visitor amenity of the Park. The fact that the Mistletoe coverage was in such a prominent position, may also reinforce inappropriate perceptions regarding the important ecological values of Mistletoe.

The way in which land managers perceive Mistletoe and its ecological role can be related to the manner in which they manage land. The broader the base of information available to the land managers, the better equipped they are to make decisions. Biological information on the functional role of Mistletoes in terrestrial ecosystems is not readily available or accessible to environmental practitioners in general. A large portion of the material available is in the form of technical papers of interest to the scientific community, but with restricted practicality to land managers. Nick Reids 'Managing Mistletoes' (1996) and the 'Land for Wildlife' Newsletters are admirable attempts to fill this void. This problem is not restricted to the study of Mistletoes but is part of a general problem of communication and information flow between the scientific community, the general public and land managers. It is a crucial problem to resolve and find solutions for the 'best practice' management of our indigenous biota.

Conclusion

The environmental practitioners displayed a common-sense approach in their management of Mistletoe. Although no active management had occurred, concern for heavy incidences of Mistletoe-hosting trees had lead to formulation of what was acceptable levels of foliage replacement. When decisions are made to actively manage Mistletoe in any of the Parks, the work must be planned and recorded in detail, with clear objectives stated for the program. Secondary affects of Mistletoe removal such as possible displacement of Butterflies, Honeyeaters and Possums. should be considered and monitored. Removal of Mistletoe plants may well be a short term, possibly unsatisfactory solution, as has been reported in Land for Wildlife Newsletter (1.4) and an integrated management solution, the desired option (Reid 1996). The interest that the Questionnaire stimulated in the environmental practitioners may well result in further work on the distribution and abundance of Mistletoe at a Park level. In between the time of carrying out the Questionnaire and completing this paper, further refinements to the answers were made by several practitioners. This is important because it is probable that perceptions play a stronger role in Mistletoe management throughout the land management community, than biological information. It would be of some benefit to extend the Questionnaire to Parks Victoria visitors so that their perceptions of Mistletoe are also recorded. There may be some community concern regarding the ecological role of Mistletoe and that may need to be addressed through educational literature.

Mistletoe Ecology in Melbourne's Bushland

Digby Race[1] and Fleur Stelling[2]

Introduction

In this paper we discuss our study which sought to identify the interactions of mistletoe with its environment and to determine whether mistletoe is contributing to the decline of Melbourne's remnant vegetation. The study was conducted during 1987-88 in association with Burnley College-The University of Melbourne (formerly VCAH-Burnley). The six mistletoe species Buloke Mistletoe *Amyema linophyllum*, Box Mistletoe *A. miquelii*, Drooping Mistletoe *A. pendula*, Grey Mistletoe *A. quandang*, Creeping Mistletoe *Muellerina eucalyptoides* and Harlequin Mistletoe *Lysiana exocarpi*, from the Loranthaceae family, are an indigenous component of Melbourne's flora. It is common for vegetation managers to perceive mistletoe as contributing to the decline of Melbourne's remnant vegetation. Responsible management of mistletoe and host species needs to be based upon a sound knowledge of mistletoe ecology and impacts on hosts. Although relatively little is known about Australian mistletoe ecology, compared to that of the northern hemisphere mistletoe species, a negative perception of Australian mistletoe species has generally developed, with many people regarding mistletoe as a pest plant to be eradicated. While it is common for mistletoe in Melbourne to have non-indigenous trees as hosts (eg. Cherry-plums *Prunus* and Oaks *Quercus* spp.) this research is restricted to the relationship between mistletoe and the indigenous flora of Melbourne. While the plant nomenclature is according to Willis (1972) (unless specified), it should be noted that Ross (1996) lists several subspecies within the above mistletoe species which were not recorded at the time of this research.

Background

Mistletoe flowers tend to be attractive and visually conspicuous, and are usually pollinated by birds which feed on the

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abundant nectar. All of Melbourne's native mistletoe species reproduce by seed, although *Muellerina eucalyptoides* reproduces by both seed and runners. (Fig.1)

Fig.1. Creeping mistletoe *Muellerina eucalyptoides* illustrating epicortical runners.
Photo: M. Calder

The most specialised feeders on mistletoe fruit appear to be the Mistletoebird *Dicaeum hirundinaceum* and Honeyeaters *Grantiella* spp. (Reid 1986), with many other birds, insects, possums and gliders also using mistletoe as a valuable food source. Melbourne's mistletoes are believed to be semi-parasitic, producing their own energy through photosynthesis, while relying upon the host plant for the supply of mineral nutrients and water. An overview of the lifecycle of Melbourne's mistletoes is presented in Fig. 2.

The effects of mistletoes on their hosts vary depending on a number of interrelated factors, including:
• Extent of population (ie. number, size and vigour of mistletoe);
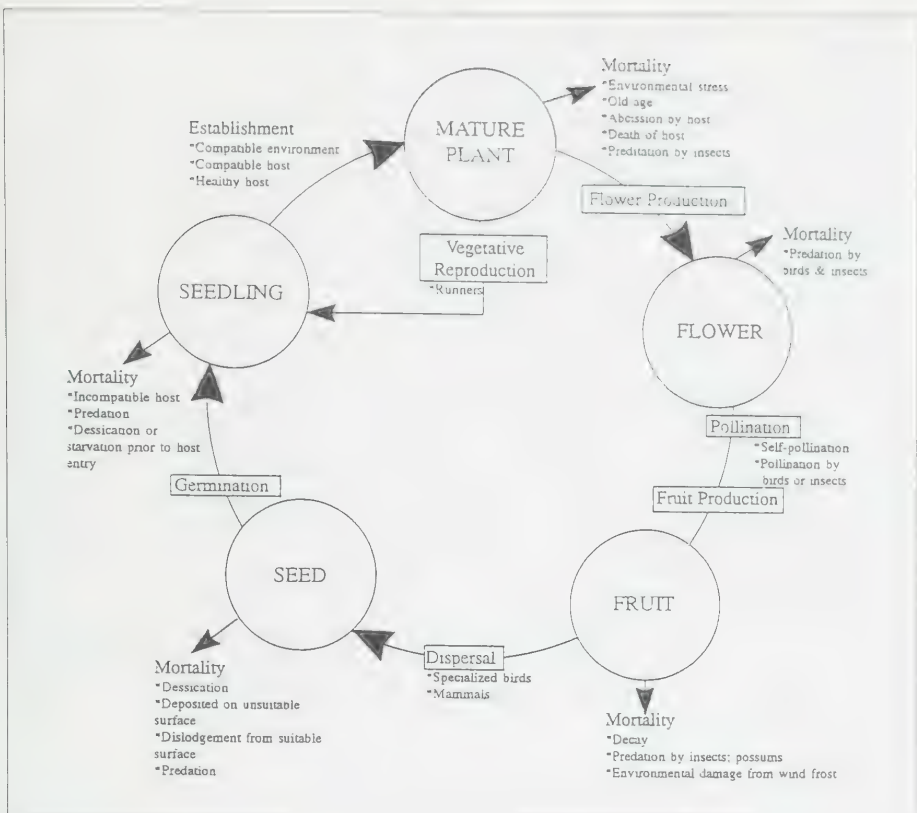
Fig. 2. Mistletoe life cycle.

- Species, age and health of mistletoe and host; and
- Environmental conditions (eg. moisture availability, insect predation).

Mistletoe has been reported to cause: the death of host branches beyond mistletoe attachment; reduced host vigour and health; poor flower and seed production, and weakened resistance to environmental stresses (Kerr 1925; Miller and Tocher 1975; Eager and Calder 1978; Fisher 1983; Knutson 1983; Lamont 1983; Sullivan and Venning 1984).

Dieback of supporting limbs of the host is a common symptom noted by those observing mistletoe-host relationships. Room (1971) noted that host branches beyond some mistletoe species were killed due to severing of the supply of water and mineral salts by the mistletoe. Lamont (1983) concluded that the death of host branches beyond mistletoe can be explained equally by the export of nutri-ents out of the host's branch (and into the mistletoe), as through failure to receive sufficient water and nutrients for growth.

An inverse relationship between host vigour and the number of mistletoe plants was reported by Preston (1977) and Knutson (1983). It appeared that mistletoe in excess of 30% of the host's crown caused marked growth decline in the host. Alternatively, such growth decline could be interpreted as progressive receptiveness to mistletoe establishment by weakened or senescent trees (Eager and Calder 1978). However, it was not noted whether the mistletoe may merely have been a secondary contributor to the decline in the host health, if the host was already experiencing stress due to environmental factors (eg. waterlogging) or old age. Nonetheless, a host may experience water stress due to the characteristically high transpiration rate of mistletoe, resulting in reduced host vigour (Fisher 1983).

Mistletoes' use of host nitrogen may influence host health, particularly in spring when host demand for nitrogen in young leaves and buds is high (Knutson 1983). However, Lamont (1983) casts some doubt on the above explanation of symptoms, pointing out that the relative losses of other nutrients due to the mistletoe, such as potassium and phosphorus, are comparatively much greater. Accumulation of many essential nutrients (ie. potassium, phosphorus, sulphur and nitrogen) at the mistletoe's establishment site is believed to be at the expense of nutrient supplies in the host. These nutrients accumulate early in the mistletoe's life, often before foliage develops. The host may increase its metabolism to compensate for mistletoe establishment. Extra metabolites would then become available for the mistletoe to utilise. Knutson (1983) suggested that North American mistletoe, mostly in the Viscaceae family, may receive carbohydrates from their hosts. However, no research has been cited that reports the propensity of species from the Loranthaceae family to receive carbohydrates from their hosts.

Research results

This research collected information relating to mistletoe habitat at 12 sites throughout Melbourne's metropolitan region, with the sites located in 10 suburbs: Blackburn, Keilor, Frankston, Mount Eliza, Diamond Creek, St. Andrews, Kew, Strathmore, Glen Waverley, Park Orchards. A survey sheet to record relevant mistletoe-host details was completed for every host plant and its mistletoes encountered at the selected 12 sites. Characteristics such as mistletoe and host age and health, and extent of vegetation disturbance were subjectively assessed. For instance, the health of the host and mistletoe were individually assessed on the combined basis of foliage density, amount of dead wood present and the plant's overall appearance.

The research recorded the characteristics of 706 mistletoes and their 208 hosts. Most of the hosts were eucalypts and were estimated at between 45 and 80 years old. The
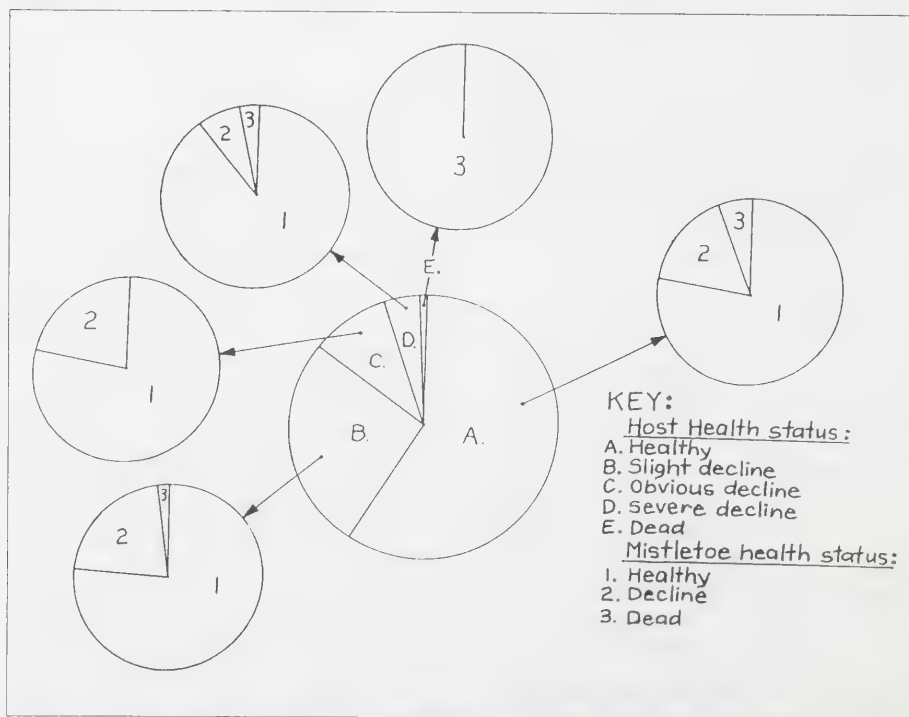
Fig. 3. Mistletoe health relative to host health. (No. of surveys = 208.)

majority of the 208 hosts surveyed (57%) were assessed as being healthy (Fig. 3: Mistletoe health relative to host health). Interestingly, of the 15 hosts assessed as heavily populated by mistletoe, 60% were 'healthy'. Also, the three mistletoe species recorded (*A. miquelii, A. pendula, M. eucalyptoides*) were most frequently assessed as being healthy (Fig. 3). Death of the supporting limb or death of the host appeared to be reasons for mistletoe mortality .

Host trees heavily populated with mistletoe were often recorded in clusters of trees of a single species. The neighbouring trees usually had considerably less mistletoe but were also of a healthy status. It appeared that if a healthy tree experienced stress (eg. root damage, drought) it would abscise some of its foliage to compensate for the stress. The high transpiration rate of mistletoe may also be harmful to a host experiencing stress, as noted in the literature above. The host may then compensate for the stress by compartmentalising (closing off) the branch supporting mistletoe. Seven hosts were noted with dead mistletoe while remaining healthy themselves. From these results, it is suggested that a host may not necessarily recognise mistletoe as harmful until it experiences severe environmental stress. Most hosts (57%) surveyed were recorded as being 'healthy'.

The position of mistletoe plants amongst host canopies was strongly correlated with an open environment. Drooping Mistletoe and Box Mistletoe occupied terminal positions on host branches more frequently than Creeping Mistletoe. This tendency of Creeping Mistletoe was attributed to its creeping habit, allowing it to establish closer to the host's trunk following initial seedling establishment on outer branches.

Discussion

Of the wide range of host species colonised by *A. pendula* and *M. eucalyptoides*, most were found on *Eucalyptus* species. This would appear reasonable as eucalypts dominate the upperstorey of much of Melbourne's remnant bushland. Black Wattle *Acacia mearnsii* and Blackwood *A. melanoxylon* were observed as less frequent hosts for *Amyema pendula*, as was Black Sheoak *Allocasuarina littoralis* (Ross 1996) for *M. eucalyptoides*. While it is common

for *A. pendula* and *M. eucalyptoides* to have non-indigenous trees as hosts, these mistletoe-host relationships were not covered by this research.

While the *Amyema* species and *L. exocarpi* reproduce with the dispersal of fertile seeds, *M.eucalyptoides* reproduces from seeds and vegetatively from epicortical runners. During the flowering and fruiting seasons of *A. pendula*, substantial defoliation was noted on plants that produced large quantities of flowers and fruit. Mature *A. pendula* plants that produced smaller quantities of flowers and fruit maintained their dense foliage. The normal annual process of leaf drop, coupled with seasonal predation by insect larvae (commonly Imperial White Butterfly *Delias harpalyce*) may cause the defoliation of otherwise healthy mistletoe. The extent of reallocation of resources in defoliation was realised when a Drooping Mistletoe plant was isolated from potential insect/animal predation as part of this study. During the plant's long fruiting season (approximately 7 months) it became substantially defoliated. It appeared that its 'decline' status was part of this healthy plant's annual defoliation process, indicating that the physical state of mistletoe needs to be interpreted carefully. It is believed that *A. miquelii* and *M. eucalyptoides* also reallocate internal resources causing defoliation, but to a lesser extent than *A. pendula*. *A. miquelii* and *M. eucalyptoides* appeared to have shorter reproductive phases than *A. pendula*. All three species were recorded in one locality (St. Andrews), with staggered flowering and fruiting periods from October to April. This occurrence would present foragers of mistletoe with a continuous flower and fruit supply for seven months in this locality, suggesting an important ecological role.

If mistletoe has a debilitating effect on host health, then presumably the symptoms would tend be most apparent on hosts heavily populated by mistletoe. Fifteen heavily populated hosts (ie. hosts supporting 10 or more mistletoes) were recorded in the survey. Of these 15 hosts, 13 (87%) were assessed as either 'healthy' or 'slightly dying back'. The two remaining hosts that were heavily populated with mistletoe were dead. A closer examination of these hosts' environment indicated that they had

recently encountered substantial earth-works nearby, so perhaps contributing to the death of the hosts. By randomly find-ing most hosts in a state of good health when supporting numerous mistletoe, the results contrast with much of the reviewed literature which states that mistletoe reduces the health of its host.

It was often difficult to distinguish between individual *M. eucalyptoides* plants due to their ability to reproduce vegetative-ly, resulting in a 'creeping' habit. An apparent immature *M. eucalyptoides* may either have recently separated from its par-ent plant, be in the process of separation, or simply be the terminal foliage of an existing plant. The creeping habit enables the mature plant to distribute its foliage along the host's branch. As *M. eucalyp-toides* can reproduce vegetatively it is pos-sible for it to colonise the host's trunk, as noted on River Red Gum *Eucalyptus camaldulensis* at Studley Park. Initial colonisation of *M. eucalyptoides* on a host requires seedling establishment, with a mature plant then able to reproduce vege-tatively, moving towards the host's trunk. Presumably there is less chance of mistle-toe mortality from limb abscission or phys-ical damage by wind when positioned on the host's trunk. The survey recorded *M. eucalyptoides* has the ability to colonise young branches (ie. 2 years old) as well as the host's trunk (ie. 140 years old) on River Red Gum.

Conclusion

The results from the field surveys of this research suggest that mistletoe may not necessarily be harmful to its host. There was no correlation between host health and the number of mistletoe plants in this research. Field observations, together with some literature, suggest it may be possible that Melbourne's mistletoes have a symbi-otic relationship with their hosts in times of low environmental stress. As such, mistletoes may not be a primary contribu-tor to the decline in health of Melbourne's remnant vegetation. Furthermore, these results raise doubts over the legitimacy of and justification for mistletoe eradication efforts given that there appears little con-clusive evidence that mistletoe has a con-siderable impact on vegetation health.

Consequently, two important questions arise from this research:
- Is it possible that mistletoes have a symbiotic relationship with their hosts, at least when the host is not under excessive stress (eg. drought, waterlog-ging, exposure, insect predation)?
- Do mistletoes receive water and nutri-ents from their hosts in exchange for carbohydrates?

Research on carbohydrate movement between mistletoe and host for Australian species is required if the above questions are to be answered (such work has occurred overseas).

Acknowledgments

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Mistletoes in the Rural Landscape -
Getting the Balance Right

Ray Thomas[1]

Abstract

Land clearance for agriculture has resulted in widespread ecological imbalances in the rural landscape. Community concern over increasing mistletoe levels and 'dieback' have lead to extensive revegetation work by local people. There have been significant benefits for endangered wildlife, farm productivity, sustainable agriculture, and community attitudes to the local environment. (*The Victorian Naturalist*, **114**, 1997, 127-130)

Introduction

The low sedimentary foothills between Glenrowan and Benalla in north east Victoria are important habitat for several endangered wildlife species. Fragmented remnants of Mugga Ironbark Forest *Eucalyptus sideroxylon* support populations of Regent Honeyeater *Xanthomyza phrygia*, Grey-crowned Babbler *Pomatostomus temporalis*, Bush Stone-curlew *Burhinus grallarius*, Brush-tailed Phascogale *Phascogale tapoatafa*, Squirrel Glider *Petaurus norfolcensis*, and even Quolls *Dasyurus* sp.

The landscape of narrow roadside corridors, isolated farm trees and lack of understorey is obviously degraded, but has been accepted as 'normal' for generations. People have lived through decades of imperceptible ecosystem decline, and for them 'it's always been that way'.

With the advent of severe mistletoe infestations and tree dieback over recent years, however, there has been growing concern in the local community. But the underlying causes were not widely understood and the situation was left unchallenged, especially because there were no obvious financial benefits in taking action.

The emergence of Landcare, the resulting community openness to new land management practices, and an urgent need to rescue endangered species, have together been catalysts for significant change. Community education about the values and threats to the district have given people an understanding of the issues and prompted action on a large scale to address these ecosystem imbalances.

On the other hand, the continuing loss of old farm trees, the urgent need to rescue endangered species plus an active Landcare group (indeed the second group to form in Australia) together coupled with community readiness for new Landcare actions, has prompted community education and action on a large scale in order to address these ecosystem imbalances. Co-operation between landholders, schools, unemployed teenagers, local government, state and federal conservation agencies, community volunteers from the city, churches, scouts and youth groups has brought a wealth of expertise and effort to bear on the problem.

The benefits for landholders as well as wildlife make this a good model for engaging whole communities in ecosystem restoration. We are changing the landscape because people see there is something in it for them.

A question of balance

There were several balancing acts to get right in planning and implementing this project.

• The **ecological factors** needed understanding and acting on. What are the natural processes which keep mistletoe in healthy proportions? What keeps dieback under control? How can we restore the balances?

• The **ethical considerations:** whether to rescue stressed old habitat trees by removing the parasite, or to leave mistletoe for the many wildlife species which need it for food and shelter. This question was even more ironic because even our 'flagship' Regent Honeyeaters *Xanthomyza phrygia* use the nectar, but in many cases we needed to chop off the mistletoe before we lost the host Ironbark trees themselves!

• The **financial problems** for landholders who were already struggling to make a living. How hard would it be when we

[1] Regent Honeyeater Project, Molyullah-Tatong Tree and Land Protection Group.

asked them to lock up areas for habitat? Economic gains need to be made from conservation work in order to balance the loss of productive land.

• There were **community education issues** such as 'ownership' and 'internal drive' versus 'outsiders from the government' setting the pace. For sustainable change, perhaps landholders should steer the project, but can busy farmers really be expected to organise large scale community action when they are already working off-farm to make ends meet? And do people really believe change is possible when all they ever see is the 'nibbling at the edges'? Mainstream action was definitely necessary here.

• There were **social questions** like 'This dying landscape is the farmers' problem, they can fix it', against 'We are all implicated, society should share the cost.' Who should do the work? Who should pay?

All these factors had to be taken into account.

Background research and guiding principles

Reading of the literature indicated that mistletoes were not a problem *per se*, but rather a symptom of ecological imbalances that would have to be addressed if any long term benefits were to be achieved. The open woodland landscape produced by extensive tree clearing and the lack of understorey shrubs and herbs following decades of grazing, made conditions favourable for the proliferation of mistletoes and mistletoe birds. These same conditions also worked against the survival of the natural control agents such as possums, defoliating insects, and a range of other frugivorous birds that are more random in their deposition of mistletoe seeds.

The Landcare group was already coming to terms with the need for understorey restoration as the best long term strategy to beat their severe dieback problem, so biological control of mistletoe was a logical extension.

But many trees were already under such severe stress that some would obviously die before the ecosystem balances were restored. Both short and long term actions were required.

Anecdotal evidence from local farmers suggested that pollarding mistletoe infected trees produced healthy regrowth and

good tree survival rates. The logistics of high elevation chain-saw work on so many trees was daunting, but nevertheless possible if people were motivated and given appropriate assistance.

Investigating the injection of herbicides into host tree stems met with some disappointment. Even in the best season, average mistletoe death rates were as low as 39% as against a tree death rate of 12% (Minko and Fagg 1988). The results were unsatisfactory and not at all predictable, so that users would have to perform their own long term trials for best results. Furthermore, host tree mortality was greatest for the most severely infested trees (the very trees which needed the most help!), and in trees less than 30 cm diameter, which are, in any case, prunable by long pole-saws from ground level. We would have to look elsewhere for our short term mistletoe strategy.

Ethical considerations

Mistletoe levels were so heavy throughout the district that old trees were dying at an alarming rate. The 'do nothing' option was not an option at all because the endangered Regent Honeyeater was dependent on the big old Ironbarks for winter nectar supply. Any negative effects of mistletoe removal would be minimal, simply because there was so much throughout the district and we could not remove it all even with the most intense effort.

Our aim was clearly not eradication but restoration of the balances which keep the mistletoe in healthy proportions in a forest setting. But this would take time and we had to remove the immediate stresses to create some 'breathing space' for the suffering trees. Fencing out stock and replanting indigenous understorey would establish a balance in the long term and create better habitat for many other species as well.

Financial returns from conservation work

What is there in this for the landholders? Why would they want to be involved in habitat restoration? Research in New England and elsewhere has demonstrated substantial benefits where reduced wind speed promoted faster growth in both stock and crops. There is money in stock

shelter belts and local farmers were already going down that path. Also the spectre of losing every shade tree in a farm paddock was a powerful motivation for many landholders. It was obvious that the current sacrificial loss of stock camp trees was not sustainable.

Research by Jill Landsberg and Ross Wylie into the causes and cures for 'dieback' gave strong messages about the need for stock exclusion and nutrient reduction under trees, and the need for biological control of the insect pests which swarm uncontrollably every summer (Landsberg and Wylie 1991).

Rob Davidson also argued convincingly about the positive contributions made by insect predators such as spiders, parasitic wasps, lizards, a host of birds, and small mammals such as gliders and phascogales (Davidson 1981). Creating habitat for these farmers' friends had to make good sense.

Clever fencing could create sustainable shelter areas which give stock the required protection but keep nutrients and compacting hooves out of the tree-root zone. As a result farmers could have their habitat, pest control and stock shelter all in the one place.

There were also the undefinable emotional attachments to the landscape - people simply valued the appearance of their own living environment and wished to protect and enhance it.

Community education issues

Creating enthusiasm for large scale action would never have occurred if things had kept trickling on slowly: the Landcare group was losing its paid co-ordinator, and after-hours voluntary work just could not do the job. The project needed intensive input to get many people involved and real change on the ground instead of more talk about the possibilities.

Getting the ecological messages out to landholders was a high priority, and as a *Land For Wildlife* Officer, that job would have to be mine. Speaking to Landcare gatherings and visiting countless individual properties gave me invaluable opportunities to tell the 'win-win-win' story of habitat creation, mistletoe and dieback control, and better farm productivity. Photographic enlargements were a valuable tool to show 'before and after' pictures of the district

and what could be achieved together.

Landholders all across the district became enthusiastic when they saw the common sense of our approach, and they committed areas for fencing and restoration. However, the project was clearly going to need extra resources from outside the group.

A group of unemployed teenagers was gathered to form a LEAP team to provide an ongoing work group to help the farming community. This team and all the schools in the district were introduced to the Box-Ironbark forests through trips to the best and worst areas in the region. Activities were organised to help students experience the values, learn about the ecological balances, and see the serious threats for themselves. Their responses were predictable but genuinely their own - seed collection, propagation and replanting the bush to help the endangered species. Teachers too have welcomed the project as a down-to-earth, local context through which they can meaningfully involve students in environmental issues.

Team work with Fran Sorensen, *Young Landcare* Officer for the group, has made it possible to involve all of the schools serving the catchment community.

Social questions

In an area that was cleared under government decree only a few decades ago and where mistletoe, dieback and salinity are now serious threats to sustainable production for the whole society, it is hard to ask the farmers of today to pick up the tab for all of us. The work of clearing the land took several generations and it will take several more to repair the damage. We all need to lend a hand.

Grants for fencing and educational trips were successfully obtained from both federal and state agencies as well as some corporate sponsors. A major contribution has come from the department's salinity budget because many of the Ironbark habitat restoration works have occurred on hills which are classic ground-water recharge sites.

By involving eight local schools, a LEAP group, and volunteers from the city, we have shared the workload around and provided enormous encouragement for landholders to take action. Left to their own devices, it would have to stay on the 'wish list' for many ageing or over-busy farmers.

On-ground action

Thirty-five of the 36 landholders approached to date have welcomed the opportunity to tackle the problems. About 25 km of fencing was erected in the first year of the project, and 15,000 indigenous trees and shrubs were planted over the spring of 1996. Students and the LEAP team propagated 8,500 of these from the seed they had collected on local roadsides.

Mistletoe was manually removed from selected trees on 35 properties. We began with hand saws on extension poles and later received support from the regional electricity authority, *Eastern Energy*. The authority and its six sub-contractors each donated a weekend's work on cherry pickers removing mistletoe from over-stressed trees to buy some time while the understorey is being restored.

We have many demonstration sites, ranging from ¼ ha to 10 ha, that show the ecological, social and economic benefits of our approach. We are increasing tree density and restoring understorey plants to protect irreplaceable old habitat trees and, quite fortuitously it seems, the results will be precisely what Regent Honeyeaters prefer. Old-growth large trees emerging above a canopy of younger specimens have much greater nectar flows and are particularly favoured by honeyeaters. We are saving a crucial wildlife resource that cannot be replanted in any short or medium term project.

Despite the difficulties, the project has become a mainstream, rather than a fringe, group activity, and is gaining further momentum as the wider community and several government agencies add their strong support to the farming community. It seems we have attained a workable balance and it is changing the landscape around us!

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Creeping Mistletoe *Muellerina eucalyptoides* in Suburban Melbourne

John Seebeck[1]

Introduction

Of the twelve species of native mistletoe recorded from Victoria (Willis 1972), only one, the Creeping Mistletoe *Muellerina eucalyptoides,* has been able to transfer its parasitism to introduced trees. It is epiphytic on members of the Birches *Betula*; Plums and Cherries *Prunus*; Oaks *Quercus*, and Pepper Tree *Schinus* as well as its natural host, *Eucalyptus* spp. (Willis 1972). The introduced genera are typically represented in suburban streets and gardens by Silver Birch *Betula pendula,* Pin Oak *Quercus palustris*, Scarlet Oak *Q. coccinea,* English Oak *Q. robur,* Pepper Tree *Schinus molle* and Cherry-plum *Prunus*

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cerasifera (whose cultivar *P.c.* 'nigra' is very widely used as a street tree).

This paper describes the occurrence and distribution of Creeping Mistletoe on planted trees in the suburb of Heidelberg, and notes a number of other occurrences in other suburbs.

Methods

Following preliminary observations in various streets adjacent to the Arthur Rylah Institute, Brown Street, Heidelberg (my then workplace), and noting the incidence of mistletoe on street and garden trees, I selected a sample area to investigate in detail (Fig.1). The study area encompasses an area of just over 300 ha and has some 40 km of mostly residential streets but I was unable to investigate trees
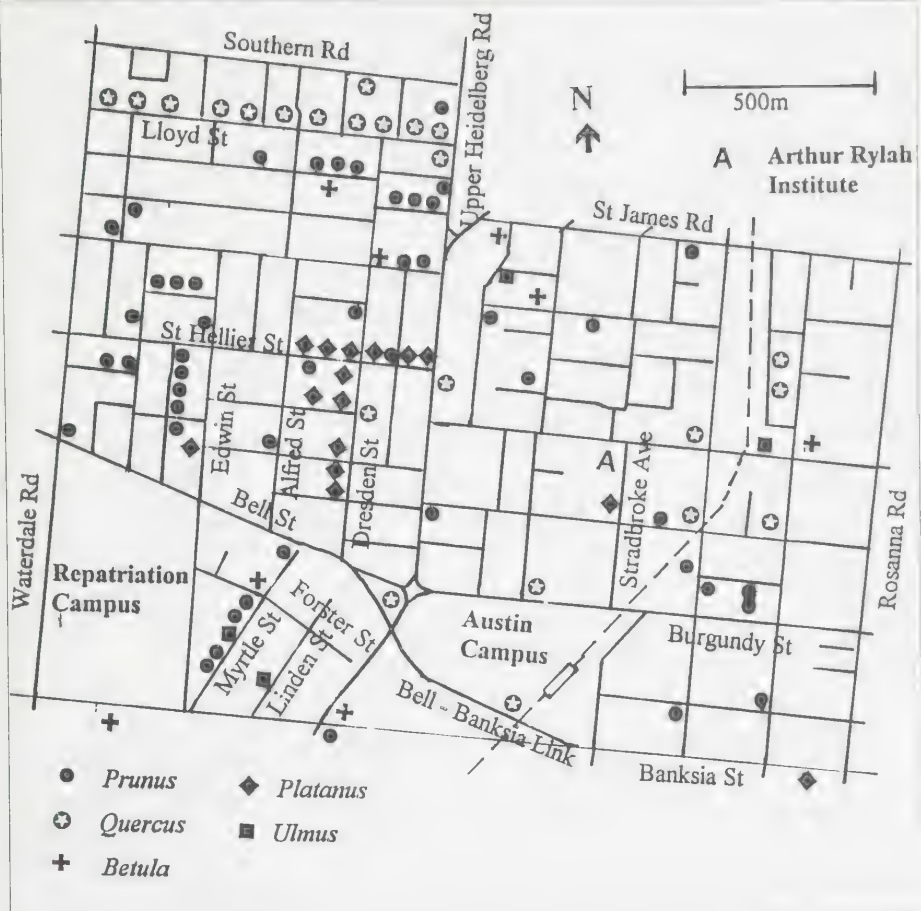
Fig. 1. Map of study area.

in the grounds of the two campuses of the Austin Hospital (Austin and Repatriation) which occupy about 28 ha on the southern boundary. The Bell-Banksia Link was not included since no trees were planted along this roadway and the deep cutting precluded observation of adjacent garden specimens.

The survey was carried out during August 1995, at which time the planted trees were leafless making it possible to see the mistletoe. I drove slowly along each street and noted the presence of mistletoe and the host plant on a copy of the relevant pages from a Melway Street Directory (Melway 1995). Where necessary, I stopped and, using binoculars, confirmed that I was, in fact, seeing mistletoe and not dead leaves or disused birds' nests. Where I was uncertain of the tree species concerned, I

collected specimens for identification; however, this was not done until May 1996, at which time I also checked the specific identification of the oak trees recorded.

Areas and distances were calculated subsequently.

I did a literature search in the journals *The Victorian Naturalist* (Volumes 1-112) and *The Emu* (Vols 30-95) for references to mistletoe and the Mistletoebird *Dicaeum hirundinaceum* which is the principal vector for mistletoe spread. I also examined the Department of Natural Resources and Environment's Flora Information System Database for records of Creeping Mistletoe *M. eucalyptoides* and the Atlas of Victorian Wildlife for the Mistletoebird. In addition, I checked the specimens at the National Herbarium for records of host trees.

Results

Creeping Mistletoe was frequently observed on the following trees: Silver Birch *Betula pendula;* London Plane *Platanus* x *acerifolia;*Cherry-plum *Prunus cerasifera;* and *Quercus,* mostly Pin Oak *Q. palustris.* It occurred in one or two instances only on Golden Elm *Ulmus procera* cv.Louis van Houtte, Chinese Elm *Ulmus parvifolia* and Crepe Myrtle *Lagerstroemia indica.* Few Pepper Trees *Schinus* were present and none were found to carry *M. eucalyptoides.* Pepper Trees are not deciduous but each specimen was searched using binoculars. Some planted or indigenous eucalypts had mistletoe, but I did not identify the species of either parasite or host.

The most commonly encountered host tree was Cherry-plum which was also the most widely planted street tree.

One hundred and twenty-eight trees bearing mistletoe were recorded. Of these, 64 (50%) were Cherry-plum, 29 (22.5%) were oak, 22 (17%) were London Plane and nine (7%) were Silver Birch.

Birch, Elms and Crepe Myrtle were only observed in gardens. Plane Trees were only present as street trees, while Cherry-plum and Oaks were mostly present as street trees but did also occur in gardens.

The distribution of mistletoe was not completely random (see Fig. 1). Only three records in the Planes were away from a cluster in St. Hellier and Dresden Streets. In St. Hellier Street, the infestation was limited to a 400 m section of road between Upper Heidelberg Road and Alfred Street, in which nine of 24 trees (37.5%) bore mistletoe. This plantation of London Plane continued to Waterdale Road, and consisted of 50 trees in all. Thus 82% were not infested despite the nearby source. In Dresden Street, six of 17 trees (35%) were infested. In contrast, there was only one instance of infection in Edwin Street (out of 19 trees) and one in Stradbroke Avenue (out of 22 trees). These four streets were the only ones in which London Plane had been planted.

Along the whole length of Lloyd Street 15 of 49 Pin Oak which had been, planted as street trees were infected. Other infestations on Oaks were found to be randomly scattered, although there was a loose grouping in the eastern part of the study area. Such isolated trees often bore a heavy mistletoe load. In Forster Street, where the only street planting of English Oak (16 trees) occurred, there was no infestation at all, despite there being a major infestation on the Cherry-plum in adjacent Myrtle Street.

Because of the perceived high incidence of infection of Cherry-plum, I sampled nine streets that were extensively planted with this species. Of a total of 151 trees, 37 (25%) had mistletoe present. The range of infestation per street was between 1% and 57%.

The Flora Information System Database revealed that Creeping Mistletoe occurred in 88 quadrats in the Melbourne metropolitan area. Eighteen of these (21%) recorded introduced tree species, of 10 identified forms. *Cotoneaster* (2 species) was present in 13 quadrats, Cherry-plum in 12 and English Oak in four. Two quadrats had no tree species recorded. All others had at least one species of eucalypt, of which 15 species were recorded.

Unfortunately, no specific links between Creeping Mistletoe and its host were recorded in the quadrat lists, so it is not possible to use these data to add to the overall distribution pattern of the mistletoe on introduced trees.

About 45% of the the National Herbarium specimens of Creeping Mistletoe collected in Victoria had host-plant information available. Included were seven species of *Eucalyptus,* two of *Acacia,* Coast Tea-Trea *Leptospermum laevigatum,* Swamp Paperbark *Melaleuca ericifolia* and *Allocasuarina* sp. Decidous hosts recorded were English Oak (Brighton, Anon. 1915, Studley Park; Oak. (Greensborough); Pepper Tree (Mentone, Anon. 1915, Cherry-plum (Hawthorn); Golden Elm (Everton, NE Victoria); Pomegranate *Punica granatum* (Beaumaris); and Hawthorn *Crataegus* sp. (Cowes, Phillip Island).

The Atlas of Victorian Wildlife contains some 4700 records of the Mistletoebird *Dicaeum hirundinaceum* for Victoria and the species occurs throughout the State. Within the Melbourne area there were about 550 records, covering most blocks and there were at least 40 records for the Heidelberg area. It seems therefore that the

Creeping Mistletoe's principal vector is well able to spread the seeds in suburban environments.

A number of other bird species and Flying-foxes *Pteropus* spp. are reported to eat mistletoe berries. Blakely (1922) listed 12 species, including Thornbills *Acanthiza* sp., Finches, Honeyeaters, Thrushes, Black-faced Cuckoo-shrike *Coracina novaehollandiae* and Common Starling *Sturnus vulgaris*, while Keast (1958) and Coleman (1949, 1951) reported Pied Currawong *Strepera* sp. and Silvereye *Zosterops lateralis*. Although none of these reports specifically incorporated feeding on Creeping Mistletoe, there is clearly a potential for spread by species other than Misteltoebird *Dicaeum hirundinaceum*. [The rare Painted Honeyeater, *Grantiella picta* is reported to be almost as dependent on mistletoe as *Dicaeum* (Hindwood 1935, Chisholm 1936, Littlejohns 1950, Gannon 1966), but it is an unlikely vector in suburban Melbourne. Indeed, Littlejohns (1948) argues that the perching behaviour of *Grantiella* is not conducive to seeds being lodged on branches].

Being now attuned to looking for mistletoe in exotic trees. I have observed it in a number of suburban streets, in the same genera of trees as in my study area. These are but casual observations and no doubt many instances are not noted, partly because it is not safe to be looking at the tree tops while driving!

Some of my suburban records are:

Silver Birch: East Hawthorn, Ivanhoe, Camberwell, Heathmont

London Plane: East Melbourne, Ivanhoe, South Yarra, Collingwood

Pin Oak: Ivanhoe, Bulleen, North Blackburn, Box Hill, Kew, Hawthorn, Canterbury, Surrey Hills, Heathmont, Croydon

Cherry-plum: Bulleen, Lower Templestowe, Blackburn

Other suburban records, which are presumed to be of Creeping Mistletoe, are Pepper Tree, Mentone (Anon. 1915); Apple (*Malus* sp.), Blackburn (Coleman 1949) and Elsternwick (G.Durham *pers.comm.*); English Oak, Brighton (Anon. 1915); Liquidambar *Liquidambar styraciflua*.

Mistletoe in *Prunus*, Templestowe Road, Bulleen, 9 August, 1995.

Mistletoe in Plane tree, Ivanhoe Station, 8 August, 1995.

locality not specified (Marshall 1981); Pear (*Pyrus* sp.) and Almond *Prunus amygdalus*, locality not specified (Hart 1941). Hart also reported mistletoe in oak trees at Bairnsdale. Lord (1939) reported cleaning germinating mistletoe, (perhaps Creeping Mistletoe), from Quince *Cydonia oblonga* trees, although this was in Queensland (Creeping Mistletoe does occur there).

Discussion

Why does Creeping Mistletoe *M. eucalyptoides* infest this disparate suite of introduced tree species? There are no patterns to be seen in the taxonomic array, nor in the type of bark carried by the different species. Why are the Elms *Ulmus* so rarely infected? It is widespread in streets, parks and gardens, as well as having a furrowed bark and a dense and sheltering canopy; similarly, Liquidambar. I have examined hundreds of specimens and have yet to see Creeping Mistletoe present, although it has been reported (Marshall 1981). Why not Ash *Fraxinus*, Maple *Acer* or Poplar *Populus*? There are many seemingly more-suitable garden trees that are not infested. I did not investigate garden-growing fruit trees, but reports such as that of Coleman (1949), Hart (1941) and Lord (1939) suggest that mistletoe might be commonly found in older gardens or remnant orchards.

Does the age or size of the tree have any effect on the potential for infection? Most London Plane and Pin Oak that I observed to be infested were 'mature' specimens, with a large trunk diameter. However, many Cherry-plums were quite small. Mistletoe itself takes several years to establish and may not produce flowers or fruit until it is 4-5 years old (Littlejohns 1948). In May 1996 a large plant of Creeping Mistletoe was removed from a decorative apple *Malus* sp. that had been planted about 20 years earlier. However, no information is available as to when the mistletoe was first seen (G. Durham *pers.comm*).

Most authorities maintain that the Mistletoebird is the principal vector in dispersal. Are introduced birds, more common in suburban Melbourne, involved? Blackbirds *Turdus merula*, Common Starling *Sturnus vulgaris* and Common Mynah *Acridotheres tristis* would seem to be good candidates.

Many questions have emerged from this short study. I am interested in receiving records of Creeping Mistletoe *M. eucalyptoides* in introduced trees from anywhere in Melbourne, and also comments on seed dispersal agents. Field naturalists are ideally placed to seek answers to some of my questions, and I encourage such an activity.

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Behaviour, Voice and Breeding of the Mistletoebird *Dicaeum hirundinaceum* in Arid Woodland

Nick Reid [1]

Abstract
A study of the behaviour, foraging, site fidelity, voice and breeding of Mistletoebirds *Dicaeum hirundinaceum* was undertaken in arid low open woodland near Whyalla, South Australia, between 1980 and 1984. The species usually occurred singly or in pairs, and males defended territories of 13-25 ha. Although birds occurred in the area throughout the year, inter-annual site fidelity was low: only two of 14 birds remained in the area in which they were mistnetted after a year or more. Territorial males chased other males in high-speed weaving flights over territorial boundaries throughout the year, but mainly between August and January. Males also chased mates in courtship, mainly between July and September. Mistletoebirds employed different handling techniques for structurally different mistletoe fruit (*Amyema* and *Lysiana*) and spent a small part of foraging time searching for arthropods. Arthropods rose to 56% of foraging time at the start of moult in March, when ripe mistletoe fruit was abundant. Birds repeatedly flicked their wings while foraging for arthropods and mainly gleaned branches and snatched and hawked arthropods inside tree canopies. Mistletoebirds had several calls, including a general song, flight call and subsong given by both sexes, a territorial song and excited warble given by males, and distress and juvenile calls. Breeding activity declined during the study due to drought, but egg-laying must have occurred between July and September and November and January in most years, straddling the annual decline in ripe fruit abundance of Grey Mistletoe *Amyema quandang*. Nests were constructed in Bullock Bush *Alectryon oleifolius* and Western Myall *Acacia papyrocarpa*. (*The Victorian Naturalist* **114**, 1997, 135-142).

Introduction

The Mistletoebird *Dicaeum hirundinaceum* is distributed throughout mainland Australia (Blakers *et al.* 1984) and is common in many districts. Due to its predilection for mistletoe fruits and confiding behaviour near the nest, much has been written about the bird's association with mistletoe (Chandler 1912; Littlejohns 1948; Keast 1958; Liddy 1983; Reid 1986) and the bird's breeding behaviour (Lawrence and Littlejohns 1916; Littlejohns 1943; Chaffer 1966; Ballingall 1990). Banding studies have also produced detailed information about the Mistletoebird's diet (Liddy 1982), moult and plumage (Liddy 1984). Nevertheless, during the preparation of a review of Dicaeidae (Reid 1997), little information was found about the behaviour, daily routine and annual cycle of Mistletoebirds.

Between 1980 and 1984, I studied the mutualism (mutually beneficial relationship) between mistletoes and birds near Whyalla, South Australia. Mistletoebirds were continuously present in Western Myall *Acacia papyrocarpa* woodland, in association with the continuous fruiting of abundant Grey Mistletoes *Amyema quandang*. Details of mistletoe dispersal by

Mistletoebirds (Reid 1989), their diet and population dynamics (Reid 1990) have already been published. This paper reports observations of the species' foraging behaviour, calls, courtship behaviour, territoriality and breeding.

Methods

The study was conducted along a 3.3 km traverse, 2-5 km north of the homestead on Middleback Station (32°57'S, 137°24'E). The climate is arid with a mean annual rainfall of 210 mm. Precipitation fluctuated widely during the study: good seasonal conditions were experienced in 1980 and 1981; 1982 was dry, culminating in severe drought in the summer of 1982-83. Drought-breaking rains in March 1983 provided temporary relief but conditions were again dry in the following summer. The vegetation was low open woodland dominated by Western Myall, with scattered stands of False Sandalwood *Myoporum platycarpum*. A variety of small trees and tall shrubs, particularly Bullock Bush *Alectryon oleifolius* and *Exocarpos aphyllus*, occurred sparsely through the woodland, above a continuous open cover of Saltbush *Atriplex* spp and Bluebush *Maireana* spp. Reid and Lange (1988) and Reid (1990) provide further details of the climate and vegetation.

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I visited the area every month between June 1980 and December 1983, as well as occasionally prior to and after those dates. The periods spent in the area are shown in Fig. 1. Mistnets were erected in December 1980 and every two months between November 1981 and November 1982. The original intention was to colour-band Mistletoebirds that were retrapped, but as none were retrapped, only three were colour-banded opportunistically in December 1980 (a male) and July 1982 (a male and female). Notes were made on the species' behaviour, voice, agonistic interactions, courtship, breeding and foraging as opportunities arose throughout the study. Fifteen hours of time budgets (timed continuous observations) of Mistletoebird activities were collected between November 1981 and December 1982 (see Reid 1990).

Between March and July, birds were relatively inactive and easy to observe. Contact was more difficult to maintain between October and January, when birds frequently moved between trees and traversed hundreds of metres rapidly. However, long periods (>10 min) of uninterrupted data were obtained in each month. Contact was maintained with individuals for an average of 203 seconds. Interactions between birds involving territorial defence and courtship were scored on a daily basis because birds indulged repeatedly in such activities on any one day.

Mistletoebird abundance and diet

Mistletoebirds occurred year-round in low density (Reid 1990). Numbers fluctuated somewhat, decreasing at the height of the drought (summer of 1982-83) and in the two months immediately thereafter. Census data also displayed a weak annual cycle, with
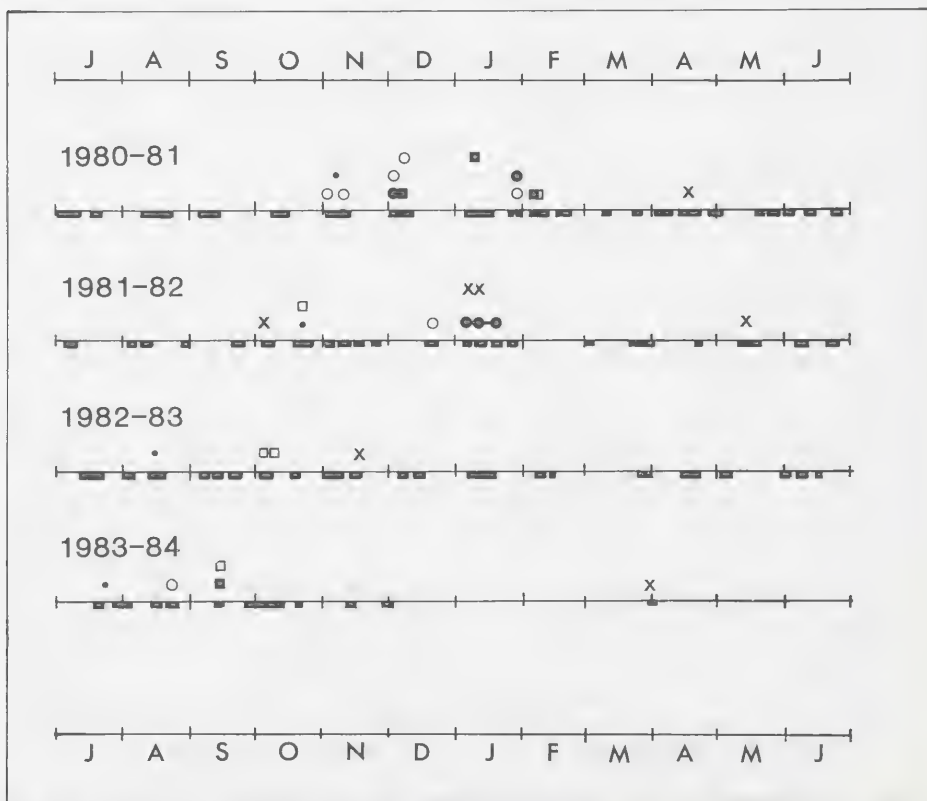
Fig. 1. Evidence of Mistletoebird breeding. The black bars on the datelines indicate periods spent in the field. **Key to symbols**: •, collecting nesting material; ○, nest under construction; ◉, nest with eggs; ■, nest with young; □, dependent young out of nest; x, independent juveniles.

high counts between May and February and low counts in March-April, correlated with the territorial and non-territorial phases in male behaviour (see below). Mistletoebirds subsisted largely on a diet of *Amyema quandang* fruit throughout the year. Foraging for arthropods occupied 15% of foraging time in winter and 32% of foraging time in summer. Small quantities of Harlequin Mistletoe *Lysiana exocarpi* fruit and *A. quandang* nectar were taken in winter (Reid 1990). In the study area, the only other food item recorded was a single fruit of *Exocarpos aphyllus*. However, at the shearers' quarters near the homestead, Mistletoebirds frequently ate the fruits of Peppertrees *Schinus areira*.

Results
Behaviour

Mistletoebirds usually occurred alone or in pairs. In autumn and winter, individuals often spent periods of an hour or more without moving more than a few metres in the one grove of trees. They interspersed foraging bouts in mistletoes or adjacent tree canopies with preening and rest periods lasting up to 10 minutes. Resting birds often sat with feathers puffed up and sometimes indulged in subsong. A rest period usually terminated with wing and leg stretching, defecation of a string of mistletoe seeds, and a return to foraging or flight.

Mistletoebirds rarely congregated. Three males fed on *Amyema quandang* fruit and rested together in a Western Myall grove for an hour in March 1982 with little agonistic interaction, and a male and two females fed on *Lysiana exocarpi* fruit in the one tree in July 1982. Several birds sometimes fed together in Peppertrees in spring. All seemingly agonistic interactions initiated by Mistletoebirds (n=28) were initiated by males and were directed towards other males (n=13), females (n=11) or other species (n=4). Males often chased each other but also harassed Inland Thornbills *Acanthiza apicalis* on two occasions and a Yellow-rumped Thornbill *A. chrysorrhoa* and Singing Honeyeater *Lichenostomus virescens* on single occasions. All instances of males chasing females were thought to be part of courtship. Mistletoebirds were sometimes displaced or chased by Spiny-cheeked Honeyeaters and Singing Honeyeaters, and once by a male Red-capped Robin *Petroica goodenovii*.

Courtship behaviour was seen as early as April and as late as February, but was concentrated between July and September. Courting males variously uttered excited warbles, flitted around the female, perched near her with partly fanned tail, or pursued her in extended high speed flights through and above the trees over an area of several hectares. Territorial behaviour in males was evident throughout the year but was concentrated between August and January. Territorial males were restless, darting between distant parts of the territory and singing from exposed perches, frequently returning to the female and chasing her through the territory. Territorial males repeatedly chased neighbouring males in protracted weaving flights over several hectares near territorial boundaries.

Foraging behaviour

The structure of the fruits of *Amyema quandang* and *Lysiana exocarpi* differ, and Mistletoebirds employed different handling techniques to deal with them. *A. quandang* fruits have a firm epicarp enclosing the viscous diaspore. Birds removed the distal half of the epicarp with a peck and then consumed the protruding diaspore, sometimes squeezing the basal half of the epicarp first to slightly expel the diaspore and facilitate its removal. Birds often pecked green, overripe or parasitised fruits without removing the distal epicarp, in order to gauge their suitability. *L. exocarpi* fruits have a flaccid skin-like epicarp enclosing the diaspore (Fig. 2). Mistletoebirds removed the entire fruit and usually retired to a perch just beyond the mistletoe. The fruit was mandibulated in the bill and the diaspore slowly worked out of the hole in the epicarp left by the pedicel.

Fig. 2. *Lysiana exocarpi* fruit.
Photo R.J. Fletcher

Table 1. Foraging behaviour of Mistletoebirds in search of arthropods.

Table entries are percentages of 81 foraging attempts. A 'glean' was defined as a foraging attempt for a food item on a substrate by a bird perched on a substrate. A 'snatch' was an attempt to capture a food item on a substrate by an airborne bird. A 'sally' was an attempt to capture an airborne food item by an airborne bird. n/a - not applicable.

Site	Foraging behaviour		
	Snatch	Glean	Sally
Foliage	5	20	n/a
Branch	9	42	n/a
Space within canopy	n/a	n/a	21
Space beyond canopy	n/a	n/a	4

After swallowing the diaspore, the bird often continued to mandibulate the epicarp, presumably sucking out remains of the viscous mesocarp, eventually dropping the evacuated skin. Handling time between the time the fruit was picked and the epicarp discarded, averaged 42 secs (range 14–71 secs, n=8).

When foraging for arthropods, birds searched the branches and foliage and canopies of trees and tall shrubs in a series of hops and short flips. Occasionally, individuals hovered near a substrate for a second or two to inspect it for food items. Table 1 shows the ways in which Mistletoebirds captured arthropods. Birds mainly gleaned branches and foliage but often sallied for insects in the airspace within tree and shrub canopies. When searching canopies, Mistletoebirds usually flicked both wings out from the body like a flycatcher, at an average rate of up to 18 flicks/min. Judging by bill mandibulations, birds were often successful in capturing prey, and occasionally a moth or spider was visible in a bird's bill. Prey size varied from minute arthropods too small to be seen, to moths 1.5 cm in length. Most arthropod-feeding was seen in March 1982 when it occupied 56% of foraging time and ripe fruit of *Amyema quandang* was abundant.

Site fidelity

Limited information was obtained about site fidelity and territoriality because of the low population density and the fact that sedentary individuals occupied large home ranges or territories (up to 25 ha). Only 14 individuals were mist-netted and three colour-banded. The male that was colour-banded in December 1980 was subsequently observed within a 400 m radius of the net-site in January (breeding), April and from July to October 1981. An unbanded male occupied the territory after mid-October 1981. Two males were banded in November 1981 and one or both were observed repeatedly up to 1 km away until the end of January 1982. Only unbanded males were observed from March 1982 until two males and two females were banded in May 1982. A banded male was last seen near the net-sites in July 1982 but a banded male persisted in an area 500 m away until October 1982. A banded female was seen near the net-sites in June 1982, but sightings of unbanded birds of both sexes predominated between May and July. In July 1982, a male and female were colour-banded. The male was last seen 4 days later and the female 2 weeks later. The last birds banded were a male and three females in September 1982. A banded female was seen twice near the net-sites in October 1982 but sightings of unbanded birds predominated for the rest of the year. Mistletoebirds were scarce at the height of the drought in February 1983 and after the drought broke in March. Thereafter, most sightings in the study area for the rest of the year were of unbanded birds. However, individual banded males were seen near the net-sites in April and May and 1.5 km to the north in June 1983; and a banded female was seen near the net-sites between July and September 1983 with a dependent fledgling in September.

Voice

Mistletoebird vocalisations were categorised as follows:

General song: *wissweet ... wissweet ...,* or *wit-wissweet ... wit-wissweet.* A strident two or three-note whistle given throughout the year, usually uttered repeatedly. It was sung by lone individuals of both sexes when perched or while foraging, and presumably served to advertise the presence of the caller to a mate or nearby conspecifics.

Territorial song: witsoo witsoo witsoo ..., wiss wiss wiss ..., or *wichy wichy wichy ...* A strong whistling song given by territorial males between August and March. It was

sung repeatedly from the tops of dead trees, dead branches atop live trees, as well as from within tree canopies in singing bouts and while foraging.

Flight call: seep. A sharp, high-pitched, carrying whistle uttered by both sexes in flight overhead. Imitations of the call would often induce a bird to circle in flight in order to investigate the caller.

Excited warble: short buzzing warbles uttered by males and perhaps females, when a male displayed to a female, chased a female in courtship, or chased another male in territorial conflict.

Subsong: a continuous stream of subdued buzzing warbles given by both sexes throughout the year when resting or foraging, but more frequently heard outside the breeding season or from immatures during the breeding season. A female and two males mimicked other species in winter 1982 as well as including their own songs in subsong. The species imitated are listed in Table 2.

Distress trill: a female once gave a high-pitched trill when she found me close to her nest.

Juvenile call: sip sip sip ..., incessant high-pitched whistle whose location was difficult to pinpoint; given by dependent fledglings.

Breeding

Six nests were found in the summer of 1980-81 (Fig. 1) when the territorial behaviour of five pairs along the traverse was intense and their breeding behaviour conspicuous. Only two active nests were found in subsequent seasons. Since most time was spent observing birds in 1982-83, the lack of evidence of breeding in this period was due to a reduction in the amount of breeding. Breeding was recorded over several months in different seasons (Fig. 1). Based on the observations of nest-building, young in nests and dependent fledglings as well as records of nests with eggs, egg-laying must have occurred between July and September in 1981, 1982 and 1983, and between November and January in the summers of 1980-81 and 1981-82. No evidence of clutches begun in October nor in the 1982-83 summer was obtained. The spring and mid-summer peaks in breeding occurred either side of the annual decline in *Amyema quandang* fruit abundance in October-November.

Table 2. Species mimicked by Mistletoebirds during subsong.

Sex and month	Species mimicked
Female, April 1982	Mulga Parrot *Psephotus varius*
	Variegated Fairy-wren *Malurus lamberti*
	Striated Pardalote *Pardalotus striatus*
	Chestnut-rumped Thornbill *Acanthiza uropygialis*
	Yellow-rumped Thornbill *Acanthiza chrysorrhoa*
	Southern Whiteface *Aphelocephala leucopsis*
	White-fronted Honeyeater *Phylidonyris albifrons*
	Jacky Winter *Microeca fascinans*
	White-browed Babbler *Pomatostomus superciliosus*
	Rufous Whistler *Pachycepala rufiventris*
	Grey Shrike-thrush *Colluricincla harmonica*
	Black-faced Woodswallow *Artamus cinereus*
	Silvereye *Zosterops lateralis*
Male,	Striated Pardalote
	Weebill *Smicrornis brevirostris*
	Yellow-rumped Thornbill
	Willie Wagtail *Rhipidura leucophrys*
	Silvereye
Male, September 1982	Mulga Parrot
	Weebill
	Inland Thornbill *Acanthiza apicalis*
	Chestnut-rumped Thornbill
	Yellow-rumped Thornbill
	Southern Whiteface
	Jacky Winter
	White-browed Babbler
	Rufous Whistler
	Dusky Woodswallow *Artamus cyanopterus*
	Silvereye

Of eight nests, five were in Bullock Bush and three were in Western Myall. Their height above ground averaged 2.2 m (range 1.7-2.6). The contents of four nests were examined: two contained three nestlings; one contained two nestlings, and one contained a clutch of two eggs.

Discussion

The continuous production of fruit by *Amyema quandang* enabled Mistletoebirds to occur in the study area in low numbers

throughout the year. However, unlike Spiny-cheeked Honeyeaters which were sedentary and held territories in pairs in the study area over several years (Reid 1984), most Mistletoebirds stayed for a few months at most, and some remained for only a few days. The maximum recorded residences were eleven months for a colour-banded male that bred near the net-site and at least 12 months for a banded female that also bred. The loose site fidelity of the species was highlighted by the lack of a significant relationship between the abundance of ripe *A. quandang* fruit and Mistletoebird numbers over the study period (Reid 1990). Significant relationships between Mistletoebird abundance and the dry conditions were established, indicating that drought effected a reduction in their abundance. More birds bred under good seasonal conditions in Spring 1980 than in subsequent years, as well.

The transitory occurrence of many Mistletoebirds in the study area suggests that most of the population were itinerant apart from the time required to establish a territory and breed. Fewest birds were seen after the drought-breaking rains in March 1983 when abundant ripe *Amyema quandang* fruits were available, so the factors affecting Mistletoebird density in the study area were evidently partly external to it. The data support the contention that the species is 'nomadic' (Hindwood 1936; Salomonsen 1961; Blakers *et al.* 1984) in the sense that it exhibited low inter-annual site fidelity, despite occurring throughout the year at Middleback.

Mistletoebird territories in the study area were large. In spring 1980 at a time of peak breeding activity, 5 breeding pairs were distributed along a 3.3 km traverse, indicating a maximum territorial diameter of 660 m. However, tree and mistletoe densities varied along the traverse and areas of dense mistletoes were preferred to others. Areas defended as territories were 13-25 ha in extent, giving comparable densities to those found in higher rainfall districts (Blakers *et al.* 1984).

Mistletoebird behaviour while foraging for arthropods was distinctive and fly-catcher-like, given the birds' tendency to repeatedly flick the wings and their frequent capture attempts on the wing (sallies

and snatches, Table 1). Presumably, wing-flicking flushes immobile arthropods, facilitating detection and capture. Most arthropod-feeding was recorded in March 1982 when it occupied more than half of total foraging time. March probably coincides with the commencement of annual moult (Cowles 1974).

Arthropod-feeding in Mistletoebirds remains somewhat enigmatic, given the rarity of macroscopic arthropod remains in the faeces (Liddy 1982; Reid 1990). Macroscopic remains of arthropods (soft-bodied spiders) were found in only 1% of field-collected faeces (Reid 1990), but microscopic fragments of exoskeleton were detected in one of 12 samples from mistnetted birds and in two field collections. Urates (nitrogen-containing fecal material) were passed in 63% of field-collected faecal samples. Given the amount of arthropod foraging undertaken by Mistletoebirds, what happens to the undigested remains? First, given the highly-reduced gizzard of dicaeids (Richardson and Wooller 1988), Mistletoebirds probably specialise on smaller, soft-bodied arthropods such as spiders, moths and insect larvae which are easily crushed in the weakly muscularised stomach. Dammerman (1929) commented that the gizzard of the Malaysian dicaeid, *D. trochileum*, was always full of small spiders. Docters van Leeuwen (1954) observed *D. trochileum* feeding on small spiders and insects and recorded chironomid larvae and spiders in the gizzard of *D. sanguinolentum*. Cleland *et al.* (1917) recorded spiders, moths, syrphid flies, and aphids in the gut of two Mistletoebirds. Rose (1973) recorded four male argiopid spiders in a Mistletoebird gizzard, and Balingall (1990) noted that most of the arthropods fed to Mistletoebird nestlings were either too small to see or spiders. Second, given the fact that the gizzard is reduced to a diverticulum (appendix), arthropods may remain in the gizzard until reduced to minute fragments. Third, the microscopic remains may be undetectable to the human eye when returned to the intestine and defecated with mistletoe seeds. Alternatively, Desselberger (1931) and Docters van Leeuwen (1954) suggested that chitinous remains were regurgitated as pellets. Since no-one has recorded dicaeids

regurgitating arthropod remains, the latter suggestion is unlikely, unless pellets are regurgitated nocturnally.

Mistletoe fruit structure markedly affected the way in which birds harvested the fruit of *Amyema quandang* and *Lysiana exocarpi*. The encapsulate fruit of *Amyema* were rapidly harvested by pecking off the top half of the rigid epicarp and ingesting the protruding diaspore. The soft-skinned fruits of *Lysiana* required a much longer processing time, birds sometimes spending over a minute mandibulating the fruit until the diaspore was extracted from the flaccid epicarp and swallowed. Yan (1993) described the same contrasting behaviours in Mistletoebirds feeding on *A. preissii* and *L. exocarpi* fruits in the Murray Mallee. Judging from literature descriptions, Mistletoebirds process the fruits of *Muellerina celastroides* (Blakely 1922), *Dendrophthoe* (White 1946) and *Lycium ferocissimum* (Watson 1955) in the same way as *L. exocarpi* fruits, and *Dicaeum trochileum* handles the fruit of *Dendrophthoe*, *Elythranthe*, *Lepeostegeres*, *Macrosolen* and *Scurrula* similarly (Docters van Leeuwen 1954).

Mistletoebirds generally occurred individually or in pairs, with only two instances of three birds feeding close to each other in autumn and winter and several birds sometimes tolerating each other while feeding in fruiting Peppertrees in spring. This accords with literature observations of the tendency to occur in ones and twos (Cowles 1974; Reid 1983), or in larger non-breeding congregations around concentrated food sources between autumn and early summer in south-eastern Australia (Quinn 1961; Bedgood 1973; Liddy 1983; Keast 1995).

Mistletoebirds initiated clutches in Western Myall woodland either between July and September or between November and January on either side of the annual scarcity in *A. quandang* fruit. Spring egg-laying coincided with ripening of the last of the old fruit crop, and early summer breeding was synchronous with the commencement of the new fruiting season. However, summer breeding was not detected at the height of the 1982-83 drought. Breeding occurred at a time of low ripe fruit abundance in spring 1981, as well as high, indicating that the standing crop of ripe fruit had at best a partial role in initiating nesting. Mistletoebirds exhibit a similarly extended, bimodal breeding season at the base of the Blue Mountains, west of Sydney N.S.W. (Keast 1958). There, the fruiting of three mistletoe species is staggered, providing fruit in both spring and summer-autumn.

The Mistletoebird's ability to nest in mid-summer in a hot, arid environment is unusual, given the degree of water stress incurred by diurnal activity at that time of year. However, the species may be buffered from water stress by its succulent diet of mistletoe fruit. Walsberg (1975) showed that the primarily granivorous House Finch *Carpodacus mexicanus* survives in desert areas without free water by eating mistletoe berries as a water source.

Mistletoebirds built their nests fairly low in small trees of Bullock Bush or Western Myall in the study area and reared two or three young. Although Mistletoebirds nest up to 18 m above the ground in forests, nests are often built in saplings or small trees even in taller vegetation (North 1907; Chandler 1912; Chisholm 1948). The usual clutch size is 3 eggs (North 1907; Austin 1918).

A catalogue of Mistletoebird calls has not previously been described, although various calls have been reported in the literature. Chisholm (1948), Cowles (1974), Pizzey (1980) and Keast (1995) described the general and territorial songs and flight call. Chisholm (1961, 1965) summarised reports of mimicry, and Chandler (1912) and Chisholm (1916) referred to the male's excited warble.

In conclusion, this 3-year study has provided detailed information about the annual cycle, breeding, foraging, agonistic and courtship behaviour, and calls of a resident population of Mistletoebirds. Less conclusive information about site fidelity and territoriality was obtained, due to the species' large home range size, low density, the restless territorial behaviour of males, and the nomadic behaviour of a proportion of the population. Further studies should consider colour-banding as many birds as possible, despite the likely rapid emigration of a high percentage of captured individuals.

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A Brief Review of the Mistletoebird
Dicaeum hirundinaceum (Shaw) 1792 (Aves:Dicaeidae)
and an Introductory Bibliography

K.N.G. Simpson[1]

Introduction

This review is not intended to be an exhaustive summary of the Mistletoebird, but represents a product prepared for the Mistletoe Forum of the Field Naturalists Club of Victoria, held in 1996. It is intended to be a general (popular) guide to literature concerning the species. Because the bird is such a wide-spread one in Australia, a high percentage of recorded bird lists over 150 years or more contain sightings. To marshall *all* of these distribution records is not the purpose of this paper, although many of those published in books and regional booklets have been included.

Taxonomy

The species was originally described by Shaw in 1792 under the genus *Motacilla* and species *hirundinaceae*. (given as 'Shaw and Nodder 1792' by Sibley and Ahlquist, 1990). A string of other descriptions and redescriptions followed: *Sylvia rubricollis* Latham (1801), *Pipra gularis* Lewin (1808), *Pipra desmareti* Leach (1814), *Dicaeum atrogaster* Lesson (1830), and *Dicaeum perdalodus* Lafresnaye (1833). The generic name *Microchelidon* was published by Reichenbach (1853). Mathews (1912) accepted *D. h. hirundinacaeum* as the nominate race and established two subspecies *D. h. yorki* of Cape York Peninsula, NE Queensland and *D. h. tormenti* of Point Torment, NW Australia.

The 1926 RAOU Checklist placed the Mistletoebird under the Family Dicaeidae: Flower-Peckers. Some books and papers include the pardalotes with the Dicaeidae, e.g. Hindwood and McGill 1958; Leach 1958; CSIRO 1969; Storr 1977; Walters 1980, Schodde (1975) separates the Families Nectariniidae, Dicaeidae and Pardalotidae. Sibley and Ahlquist (1988, 1990) place the flower-peckers in the Family Nectariniidae, Subfamily Nectariniinae, but in their own Tribe Dicaeini. Christidis and Boles (1994) have not followed this treatment, leaving

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the Mistletoebird in its traditional Family Dicaeidae, but transferring it (and the Family Nectariniidae) into the Parvorder Passerida, the Old World-evolving passerines, as determined by Sibley, Ahlquist and Monroe (1988), Sibley and Ahlquist (1990), Sibley and Monroe (1990). The Family Pardalotidae is enlarged but remains in the Australasian-evolving passerines, Parvorda Corvida, of the same authors. McAllan and Bruce (1988) include the species in the Family Nectariniidae.

English names

It has variously been called the 'Mistletoe-bird' (1926 RAOU Checklist); 'Mistletoe bird', also Australian flower pecker', and 'Australian flower swallow' (CSIRO Australian bird names index 1969); 'Mistletoebird', with 'Flowerpecker' as a prior name (RAOU recommended English names list 1977); 'Australian Flowerpecker', 'Mistletoe Flowerpecker' and 'Australian Flower Swallow' are listed by Pizzey (1980) and Longmore (1991). The Western Australian Aboriginal name 'Moo-ne-je-tang' is provided by Serventy and Whittell (1962).

Family Dicaeidae

The Mistletoebird *Dicaeum hirundinaceum* is the only Australian representative of the Asian Dicaeidae. The Family Dicaeidae has some 55-58 member species spread through the Oriental zoogeographic region of Asia.

Evolution and Colonisation

Reid (1987) suggests that the bird dependence and distribution/dispersal of two families of Gondwana-derived mistletoes, Loranthaceae; and a larger number of species which radiated after separation of the continent from Antarctica, particularly the genera *Amyema* and *Lysiana* (in Australia), occurred a long time ago, and was the result of (perhaps mid-Tertiary) coevolution with the meliphagids, an earlier evolving and radiating group of birds on

continental Australia. The mistletoe family Viscaceae is Oriental in origin, and is believed to have found its way here more recently, perhaps in the Pliocene.

Reid argues that coevolution of the genus *Dicaeum* with the Asian mistletoes, pre-adapted the Mistletoebird to use the pre-existing Australian mistletoe species once it arrived and began to establish itself some-time in the Pleistocene, even as late as the Holocene. He suggests that Torres Strait had refilled by the time the Mistletoebird arrived, and was prevented from crossing to PNG. However, PNG was fairly recently colonised by three other species, on a slightly different phylogenetic line.

Distribution
Only the nominate race occurs in Australia. Three subspecies occur on some adjacent islands. These *are D. h. ignicolle* of Aru Island, *D. h. keiense* of Kei (Kai) Island, and *D. h. fulgidum* of Tenimber (Tenimbar) Island (from Howard and Moore, 1984). It has not managed to colonise Papua New Guinea where three other species occur. A single reported record of an Australian *D. h. hirundinaceum* collected as a straggler to the Gulf of Papua is not considered reliable (Coates 1990). The specimen, once held in the Australian Museum, is now lost. The PNG species are *D. pectorale* Papuan Flowerpecker (also previously named *D. geelvinkianum* Red-capped Flowerpecker) with seven sub-species in PNG; *D. eximium* Bismark Flowerpecker of the Bismark (or New Zealand). Archipelago with three sub-species; *D. aenum* Solomons Flowerpecker, nominate subspecies only. (Coates 1990).

The range of the Mistletoebird then, extends throughout mainland Australia to the Aru Islands but **not** to Tasmania.

Habitats
The habitats from which it is recorded range from tropical rainforests and man-groves to arid interior scrubs, where they tend to be more frequent in riparian zones. Birds range from sea level coastal plains to approx. 1000 metres on average.

In wet eucalypt forests, the Mistletoebird tends to be present in mature stands of trees, not in regrowth, and also tends to be more prevalent in larger trees standing above gullies. In open country, larger woodland trees appear to be favoured.

Isolated large trees may act as 'stepping stones' or 'refuges' during cross-country flights. Such large trees and also forested patches in otherwise cleared regions may exhibit an increase in mistletoe infestation in some parts of Australia. Such excess misletoe infestations are considered to be a problem at times, but must be clearly seen as just one of the many end products of human interference with what was once normal forested country.

Description
It is a small arboreal and frugivorous species, averaging 10-11 cm in length. The wings, with nine primary feathers, are possibly longer and narrower than those of some other similarly-sized passerines. The specific name *hirundinaceum* indicates 'swallow-like' wings. Measurements of some Victorian birds are given by Rogers *et al.* (1986).

There is a smallt clinal variation in size reported, northern birds smaller than south-ern; also females in Cape York region, Queensland, differ slightly in colour from females elsewhere (Blakers *et al.* 1985; Hall 1974; Keast 1958.)

The tongue is slightly divided at the tip, also brush-tipped for feeding on nectar. There are no obvious rictal bristles.

Males have a short dark beak and dorsally are a shiny (iridescent) blue-black. There are white sides to the abdomen, each half being separated in the midline by a vertical black line commencing between the legs, and running forward to the centre of the breast. The chin, throat and undertail coverts are bright red.

Females are grey dorsally and white ven-trally, with no or only a smudgy dark central abdominal streak. The undertail coverts are pink-red. Juveniles have a pinkish bill, other-wise resemble females but may be smaller (Macdonald 1973, 1992; Pizzey 1980; Simpson and Day 1996; Slater *et al.* 1986).

Foods
There are some 1300 mistletoe species world wide; perhaps 85 species in Australia. Some 41 species of Australian birds, mainly Honeyeaters, have been recorded at mistletoe flowers of various species. Nectar is the main food item for these birds (Reid 1986). Some 33 species of Australian birds have been recorded at mistletoe fruits. Olive-backed Oriole *Oriolus saggitatus*, Silvereyes *Zosterops*

spp.and Little Lorikeet *Glossopsitta pusilla* are major consumers of mistletoe fruits, and may be dependant on them at times. Two species go further and are almost wholly dependant on them. These are the Mistletoebird itself, and the Painted Honeyeater *Grantiella picta*. However, the honeyeater is not further discussed here.

Ripe parasitic mistletoe berries are the main food of Mistletoebirds (insects are eaten when feeding young or if the fruits are in short supply). The birds are an important agent in dispersal of the fruits. The Mistletoebird does not have a muscular gizzard as do other birds. Its digestive system is an even duct through which large numbers of mistletoe berries quickly pass. The fruits travel via the oesophagus directly to the intestine through a blind sac with a sphincter opening (a diverticulum), thus bypassing the muscular stomach itself, although any insect or other food material, which does require grinding up, can pass into the stomach normally. Hard parts of such insects, are later regurgitated as tiny pellets. The rate of digestion varies, perhaps with the degree of ripeness of fruits, but is in the broad range of 25-60 minutes, with the average being reported as 35 minutes.

The sticky seed or a string of seeds connected by mucous strands is deposited on a branch, the bird allegedly standing lengthways along a branch to accomplish this. A number of recent records, however, are at variance with this 'traditional' statement, and suggest a more random deposition of seeds. The seed germinates quickly and thus parasitises another host.

Barker and Vestjens (?1990) provide evidence of eight dicotyledon Families (Anacardiaceae, Chenopodiaceae, Curcurb - itaceae, Loranthaceae, Moraceae, Myrtaceae, Rosaceae, and Solanacaceae) being utilised, as well as additional insects (unspecified) and spiders.

Breeding

The nest is a neat suspended pear-shaped purse with a side slit-like entrance and hangs from a level twig. It is made of plant-down and spider-web matted to a felt-like or silken consistency and is frequently decorated with scraps of insect frass. It is thought that the female usually builds it alone. Do males perhaps occasionally assist? I ask this question only because a *pair* of Mistletoebirds gathering fuzz from quince fruits in an orchard at Steels Creek, Victoria, was recently reported by Jane Calder (*pers. comm.* to KNGS, 1996). The breeding season extends from about September to April, but certainly varies in different parts of the continent depending on weather conditions and consequent food supply (see differing times quoted in the regional guides cited). The female also normally incubates the eggs alone. Three white, oval eggs 17x11 mm represent an average clutch. Incubation is for about 12 days and young remain as nestlings for some 15 days (McKean 1984; Beruldsen 1980). Males assist in feeding young (McKean 1986).

Nomadism

Once the season is over, non-breeding birds become highly nomadic. Solitary males are commonly seen during non-breeding seasons, presumably because females are less conspicuous. The species has adapted to a wide climatic variation. Torpidity has been recorded in very cold weather (Serventy 1970) and the Mistletoebird may normally try to avoid this by nomadism, although the true extent of the practise is not known.

Calls

The sharp (piercing), single, travelling call of the male is very high, and some humans may not be able to hear all components of the call. On the other hand, it is often by their calls that the birds are first noticed nearby or overhead. Different calls are made and variously described in the field guides and some papers (cited). Mimicry is also known.

Acknowledgements

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[Note re annotations in square brackets: Regional guides usually provide local impressions as to status of Mistletoebirds. Page references and some other information is given].

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Control of Mistletoes by Possums and Fire:
A Review of the Evidence

Nick Reid[1]

Abstract
  In the agricultural districts of southern and eastern Australia, rural communities are concerned about the death and debility of trees due to mistletoe infestation. Treatments such as pollarding and pruning mistletoes are expensive, so farmers and Landcare groups require information on preventative strategies reliant on natural control agents that will maintain mistletoes at appropriate levels. The literature is reviewed in relation to the efficacy of arboreal marsupials and fire in regulating mistletoe populations. Species of *Amyema*, *Muellerina* and *Dendrophthoe* are the preferred food of Common Brushtail Possums *Trichosurus vulpecula* and Common Ringtail Possums *Pseudocheirus peregrinus* in certain localities or seasons, and Koalas *Phascolarctos cinereus* and Greater Gliders *Petauroides volans* occasionally eat mistletoe and may reduce local populations. High-intensity fire kills 'pest' mistletoes such as Box Mistletoe *Amyema miquelii* and Drooping Mistletoe *A. pendula* but even low-intensity fire may contain them due to the slow recovery of survivors. The abundance of arboreal marsupials and frequency of wildfire and prescribed burning in timber production forests are considered the main reasons why mistletoes are not important forest management pests in Australia. On the other hand, the suppression of fire and the declining abundance or local extinction of arboreal marsupials in agricultural districts explain to a large degree the prevalence of mistletoes in those areas and perhaps the patterns of mistletoe infestation in isolated, scattered, and thinned trees, and along roads and forest and woodland edges. Landholders and catchment planners need to consider how rural environments can be restored to favour natural control agents of mistletoes. (*The Victorian Naturalist* **114**, 1997, 149-158).

Introduction

  Mistletoes (Loranthaceae and Viscaceae) occur in most shrubland, woodland and forest communities across mainland Australia, and they are abundant in many ecosystems (Barlow 1981, 1986). Since 1900, there have been repeated calls for control of mistletoes, particularly in the agricultural districts of southern and eastern Australia (Reid 1995). Box Mistletoe *Amyema miquelii*, Drooping Mistletoe *A. pendulum* and Wire-leaf Mistletoe *A. preissii* have elicited the most widespread concern, because of their tendency to kill heavily-infected host trees (Reid *et al.* 1994) and their apparent increase in rural districts. Many observers have reported increasing mistletoe populations although there are no quantitative data to substantiate regional increases in any mistletoe population. While there are abundant anecdotal reports (and some quantitative evidence) of local population build-ups, it is uncertain whether local increases in mistletoe populations are balanced by declines elsewhere on a regional scale. In fact, in the most heavily cleared parts of the Western Australian wheatbelt, *Amyema miquelii* seems destined for extinction due to loss of habitat

and dispersers (Norton *et al.* 1995).

  Observers have speculated on the reasons why local populations of mistletoe might have increased in agricultural districts. Chief among the reasons cited are the decreasing frequency of wildfire and prescribed fire and the decline of arboreal marsupials this century. As with other aspects of mistletoe biology (Liddy 1983), the evidence that fire and marsupials influence mistletoe population abundance is often anecdotal and reported in obscure locations (below). Given the continuing concern in farming districts about the impacts of mistletoes on remnant trees (Reid 1996), it is important to evaluate the reasons for local increases in mistletoe abundance and identify ways in which property and catchment planners might ensure that means of natural control of mistletoe populations can be incorporated in farm and catchment plans.

  The aim of this paper, therefore, is to review evidence of the impacts of fire and browsing by arboreal marsupials on mistletoes, and the likely role of these agents in containing mistletoe populations in natural and modified landscapes.

Mistletoes and arboreal marsupials

  Barlow and Wiens (1977) reviewed the 'considerable anecdotal' evidence that the

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Common Brushtail Possum is a major predator of Australian mistletoes, and cited six authors who suggested that the increase in mistletoe abundance in the early twentieth century was due to uncontrolled hunting and extermination of possums. Barlow and Wiens (1977) also reported the concern that decreases in mistletoe populations in New Zealand are due to predation by Common Brushtails introduced from Australia. Since their paper, further evidence has accumulated concerning the relationship between arboreal marsupials and mistletoes, and is reviewed below. The most convincing studies concern Common Brushtail Possums *Trichosurus vulpecula* and Common Ringtail Possums *Pseudocheirus peregrinus*, but the evidence is not confined to these two species. I have also quoted some older reports (Young 1937; Anon. 1945; Campbell 1948) at length, because they are little known.

The Queensland Bureau of Investigation (Anon. 1945) conducted an experimental study of mistletoes and Common Brushtail Possums in the 1930s (Young 1937) due to concern about the increase in mistletoes in the Lockyer, Fassifern, Logan, Albert and Condamine districts. Young (1937) described the experiments thus:

These animals [Common Brushtail Possums] appear to have a particular fondness for mistletoe, especially those species commonly found growing on eucalypts such as L. pendulus *and* L. vitellinus *and when offered mistletoe in with their other usual diet they always gave the mistletoe preference. Particular fondness was evinced for the mistletoe berries in all stages of maturity from species of* Loranthus, Notothixos *and* Viscum. *The fruits were always stripped from the plants before the leaves. The flowers were readily eaten. At all feeding experiments alternative articles of diet were offered such as bananas, green leaves, pawpaws, etc...*

It is noteworthy that the fruits in all stages of growth are eaten, no matter how green. This is regarded as an important factor as the fruit would thus be destroyed before the birds which appear to prefer mature berries would get a chance to distribute them...

Mistletoe was supplied to the opossums over periods of some weeks, but the animals did not appear to tire of it. Ample provision of various species of gum leaves was made in one series of experiments as well as mistletoe and it was found that approximately equal quantities of mistletoe and eucalypt foliage were eaten. In another trial with different animals, bananas, pawpaws, etc. were supplied as well as mistletoe and still the mistletoe was eaten.

In order to gain data on the actual effect of the opossum's feeding habits on mistletoe in the forest, it was decided to loose some animals in an enclosure in which were growing eucalypt trees infested with loranths. This was carried out in the Moggill State Forest near Brisbane.

The patch of trees chosen for the experiment included tallowwood, grey gum, red ironbark (Euc. sideroxylon), *Grey Ironbark* (Euc. paniculata) *Red Bloodwood* (Euc. corymbosa) *White Bloodwood* (Euc. trachyphloia) *and Yellow Stringybark* (Euc. acmenioides). *Four plants of* Loranthus pendulus *were growing on one tallowwood and one on another. The Grey Gum had one plant on it. The area enclosed was approximately one eighth of an acre ...*

... four wild individuals were trapped on the reserve itself and released in the enclosure. These animals within a short time (3 weeks) stripped the mistletoe plants of their foliage. However, within a month the animals became emaciated and all four died. All reports and references noted indicated that the opossum did not drink and consequently no provision had been made for water for them...

When the second batch of opossums (five in number) were liberated, the mistletoes had recovered their foliage, but the opossums again stripped the more conveniently situated plants of their leaves. The plants at a distance and obviously harder to get at were not so badly touched, but new shoots appeared to be nipped off. One plant was completely killed by the end of October, the animals having been present from the beginning of August. No flowers of fruits were allowed to develop on any of the plants though these appeared on loranths outside the enclosure...

Results showed that the opossums will eat mistletoe off trees growing naturally and that by preventing the development of fruits they apparently exercise control over

the spread of the loranth. The actual population of opossums necessary to kill a well established mature mistletoe plant would presumably be very large, but the prevention of the seeding should be all that is necessary.

Although no experimental work has yet been done concerning seedling mistletoes and opossums, it appears probable that owing to the opossum's obvious liking for young mistletoe shoots, the young newly germinated plants would be very likely to be destroyed by the feeding of the animals...

It is concluded ... that the opossum in sufficient numbers would act as a check on the spread of mistletoe in hardwood forests chiefly by feeding on the fruits and flowers of the loranths, but also by defoliating the plants especially by eating the new shoot. From this, it would appear that the assertion that the widespread increase in mistletoe is associated with the decrease in the opossum population, has definite foundation...

In summarising the research, the Bureau of Investigation stated (Anon. 1945):

Numerous reports from country centres in Queensland and New South Wales drew attention to the increase in mistletoe and the decimation of the possum (and koala) population. It is widely suggested that there is a causal relationship between mistletoe increase and possum destruction. This was expressed to the Bureau by a prominent farmer on the Darling Downs, who stated that, when he settled on the property, every tree (blue gums on a Condamine River flat) had its possum; now there are no possums - every tree has its mistletoe or mistletoes...

The results of cage experiments with forest possums were:-

1. Mistletoe was always given preference in the diet by the possum even mixed with

   (a) other eucalypt leaves, and/or

   (b) succulent foods such as bananas, pawpaws, etc.

2. In mixed feeding, about 50% of the food consumed was mistletoe.

3. Mistletoe fruit, flowers or buds, no matter how green, were always eaten; i.e., the bud or flower is avidly eaten before the seed matures.

4. The possums did not tire of mistletoes during some weeks of experiment.

Field experiments were then carried out with five possums in a fenced area in Moggill State Forest. These resulted:-

1. More conveniently situated mistletoes were stripped of foliage and stems and one plant killed between August and October 1935.

2. Young shoots were destroyed on more inaccessible mistletoes.

3. No flowers of fruits developed on any mistletoes in the enclosure, although they appeared on mistletoes (Loranths) outside the enclosure.

Generally, it may be stated that the forest possum demonstrated a preference in diet for mistletoe and, if in sufficient numbers, would offer a substantial check on mistletoe infestation, primarily by the destruction of immature fruits and young shoots.

It appears, however, that very large numbers of possums would be necessary to destroy the heavy infestation of mistletoe which has developed during the period of decimation of the possum, and further that the distribution of the possum through important closely settled areas would not occur naturally at an adequate rate ...

The following statistics of past destruction of possums were obtained from Mr. R.J. Munro, Department of Agriculture:-

Open Season	1926 - 2,485,876 skins
	1927 - 1,014,632 "
	1929 - 2,032,979 "
	1931 - 1,696,831 "
	1936 - 2,250,000 "
Total -	9,480,318 "

These figures do not convey the total loss.... Probably at least 20% more possums have been killed...

Although the drop in price of skins had very much to do with the non-opening of killing seasons lately, it is also a fact that in many places the number of possums had been so reduced as to make trapping or shooting unprofitable on this score also. In more closely settled areas, the possum has practically been eliminated.

Certainly, the destruction of eleven million or more animals gives point to the thesis that a substantial upheaval of natural balance has occurred. In 1919, 2,500,00 skins were marketed and 1,200,000 in 1923 according to the Australian Encyclopaedia.

If the possum species generally prefer or relish mistletoe buds and shoots as was demonstrated in the controlled tests, the destruction of so many animals could greatly assist the spread of mistletoe, and, although the possum breeds quickly, re-establishment of control could not yet be expected.

Independent reports attest to the thoroughness of trappers in the early part of the century to reduce or exterminate local and regional populations of Common Brushtail Possums. Wilkins (1928) reported that trappers had 'exterminated most, if not all, of the valuable fur-bearing animals, such as the grey and black opossum [Common Brushtail], the wallaby, and the kangaroo' in the Ebor portion of the Northern Tablelands of NSW by 1923-25. Callister and Williams (1995) commented that heavy harvests in the early part of this century were at least partly responsible for the elimination of Common Brushtail Possums from much of their range in Queensland, and for the near extinction of the Koala.

The experiments of Young (1937) and the summarised version (Anon. 1945) are the likely basis for subsequent literature reports of possums preferring mistletoe foliage to that of the host. For instance, Troughton (1965) referred to 'experiments of the Queensland Forestry Department, showing that both the seeds and leaves [of mistletoe] were preferred to a variety of leaf and other foods ... It was not only proved that mistletoe was eaten in the wild state, but actually preferred to a selection of eucalypt leaves and other foods. Even more important was the fact that blossoms and seeds of the parasitic loranth were eaten in all stages. This habit would be invaluable in preventing the spread of the mature seeds by birds'. With regard to mistletoe spread, Coleman (1949) regarded possums 'as a definite check. In my garden the foliage of a clump of *Phrygilanthus eucalyptifolius* (Creeping Mistletoe) [*Muellerina eucalyptoides*] on *Acacia adunca* was completely eaten by possums'.

Several recent studies confirm the predilection of Common Brushtail Possums for mistletoe foliage. Choate *et al.* (1987) conducted cafeteria experiments with seven captive Common Brushtail Possums near Adelaide, offering them the foliage of *A. miquelii* and its host, Pink Gum *Eucalyptus fasciculosa*. Brushtails consumed as much mistletoe foliage as host foliage when each was presented alone, and consumed significantly more mistletoe when presented with a choice. Possums chose mistletoe on more occasions and spent more time on the mistletoe than the host feeding platform, when given a choice. Analysis of five scats from two field locations with *A. miquelii* revealed mistletoe epidermis in one scat from each location, suggesting that mistletoe is a normal part of the species' diet near Adelaide. Feeding trials conducted at the same time demonstrated that the captive possums were also fond of the foliage of *A. linophylla* (J. Choate, *pers. comm.*).

Evans (1992) found that mistletoe *Amyema maidenii* foliage was the most abundant dietary item in Common Brushtail Possum scats at three sites in central Australia. In a detailed study in central Australia, J. Foulkes (1996 *pers. comm.*, 21 September) found that *A. maidenii* was a preferred forage throughout the year of Common Brushtail Possums at three sites, despite constituting only a small fraction (<0.05%) of the leaf biomass on offer. Other *Amyema* and *Lysiana* species were eaten in lesser quantities or only irregularly. Number of mistletoe species was the best predictor of sites recently occupied by possums. Foulkes also found that *A. maidenii* foliage had higher levels of phosphorus and nitrogen and higher water content and digestibility than the foliage of eucalypts and Victoria's Wattle *Acacia victoriae*.

In addition to the Australian evidence of the frequent preference of Common Brushtail Possums for mistletoe foliage, browsing by that species on loranthaceous mistletoes in New Zealand is the principal threatening process in the decline in the North Island and parts of the South Island of all four formerly-widespread species (Wilson 1984; De Lange and Norton 1996).

Some have disputed the hypothesis that Common Brushtail Possums prefer mistletoe foliage to host foliage, or are capable of affecting mistletoe densities. May (1941) received over 300 responses to a mistletoe questionnaire from foresters, agricultural workers and shire councils

throughout NSW. She summarised the responses thus: 'Two-thirds of the reports received concerning opossums claim that they control the spread of Mistletoe, the other third stating that they distribute the seeds of this parasite'. On this basis, May (1941) considered the evidence inconclusive that 'the present increase in the amount of Mistletoe is due to a decrease in the number of opossums and or koalas'. The likelihood that Common Brushtail Possums disperse viable mistletoe seeds was discounted by Coleman (1949) and Liddy (1983).

Atsatt (1983) also rejected the hypothesis that possums feed preferentially on mistletoes. He fed the foliage of *A. pendula*, *A. cambagei*, and *Muellerina eucalyptoides* to a Common Brushtail Possum along with the hosts' leaves and those of Elm *Ulmus* sp. Apart from exploratory nibbles, the possum rejected the mistletoe foliage but ate all the Elm and host samples. The animal also quickly consumed all the fruits of *A. pendula* that were offered. Given the contrary evidence above and the fact that Atsatt (1983) only used one possum, his results must be regarded as atypical. Atsatt (1983) also examined hundreds of mistletoes throughout central and eastern Australia for evidence of leaf feeding by possums, without luck. However, he did not describe evidence of leaf feeding by possums, nor was it clear whether arboreal marsupials remained in the areas in which he searched. The Common Brushtail Possum is now virtually extinct in central Australia (Evans 1992; J. Foulkes 1996 *pers. comm.*, 21 September), has vanished from much of its former range in Queensland (Callister and Williams 1995), and is now extinct in heavily cleared farming districts such as the central wheatbelt of W.A. (Hobbs *et al.* 1994).

Selective feeding on mistletoes by arboreal marsupials is not confined to Common Brushtail Possums. Porter (1990) studied the interactions between Common Ringtail Possums *Pseudocheirus peregrinus* and mistletoes in Silvertop Stringybark *Eucalyptus laevopinea* open-forest in autumn and spring 1990, near Armidale, NSW. Despite being uncommon in the site and constituting only 0.4% of total leaf biomass on offer, *Muellerina eucalyp-*

toides foliage was highly preferred and accounted for 16% of Common Ringtail Possum feeding time. The scattered plants of *M. eucalyptoides* had sparse foliage, probably as a result of possum browsing. Ringtails also ate significantly more foliage of *Amyema pendula* (28% of feeding time) and less eucalypt foliage (56% of feeding time) than expected on the basis of the leaf biomass on offer (8.0% and 91.6%, respectively).

Koalas *Phascolarctos cinereus* may also help contain mistletoe populations. Young (1937) wrote:

It has also been shown by experiment in Queensland that the koala has a definite preference for mistletoe which has been taken from certain trees. Thus in one experiment when various samples of L. pendulus *were offered to koalas the animals invariably selected for food those which had been taken from eucalypts...*

Animals for experimental work were kindly made available by Mr Claude Reid of Lone Pine, Brisbane

Mistletoe was made available to the koalas with their usual diet which consists of a number of species of eucalypt leaves All the articles of diet were offered at once The animals ate the leaves of Loranthus pendulus *freely on occasions, but at other times would not touch any mistletoe leaves. Of all the mistletoes offered only the one species was acceptable and that at irregular intervals of some days and only when the mistletoe plant was parasitic on a eucalypt. The same species on other trees was not accepted. It would appear from this that the mistletoe is only eaten by the bears as an occasional change of diet or as a source of moisture during dry weather when the leaves are succulent in comparison to the eucalypt leaves. When the bears did eat the mistletoe, however, then [sic] consumed considerable quantities at a meal. Owing to the relatively small proportion of mistletoe in the total diet over any appreciable period, the experiment was not proceeded with, although it showed that the koala was probably instrumental in exerting some control on* L. pendulus *which is one of the most important parasites of the hardwoods.*

Later, the Queensland Bureau of Investigation (Anon. 1945) revised its

opinion when referring to the same experiments, commenting that 'The indications are that the koala ... is unimportant in controlling mistletoe'. However, Campbell (1948) argued to the contrary:

It may not be common knowledge that koalas eat mistletoe, and therefore are a natural check on this parasite on gum trees. Some notes of mine at the Colin MacKenzie Sanctuary, Healesville, March, 1937, read:

*"Saw a koala seated near mistletoe (*Loranthus pendulus*), reaching for and eating the leaves of this plant." Again in April, 1939, I noted the same thing.*

Now the sequel is found. When on a recent visit I saw many mistletoes dead and others showed signs of all leaves easily reached being stripped off. One large manna gum near the entrance has fifteen clumps on it, now all dead. Another shows four dead, one living. Only north-west along the peppermint ridges are many mistletoe clumps to be found alive, but this is where the koalas seldom go, because they much prefer manna gum to peppermint. However, in peppermints adjacent to manna gums along the main track, the nibbling of the mistletoe has obviously been considerable.

The Greater Glider *Petauroides volans* has also been recorded feeding on mistletoe. Henry (1985) recorded that *Muellerina eucalyptoides* foliage constituted 3% of the diet of Greater Gliders in Boola Boola State Forest, Victoria, increasing to 10-12% of the diet during drought. Porter (1990) found that the leaves of *Muellerina eucalyptoides* and *Amyema pendula* contained significantly more water than those of eucalypt host species, so the increased preference for mistletoe foliage in drought may be due to their succulence. Kavanagh and Lambert (1990) reported several observations of Greater Gliders eating *A. pendula* foliage in eucalypts in Coolangubra State Forest, NSW, and Porter (1990) recorded them feeding once on *A. pendula* foliage near Armidale, NSW.

There are several anecdotal references to the palatability of the foliage of Australian mistletoes to domestic livestock. Moore (1899) commented that *Amyema miraculosum* (on quandong *Santalum* sp.) and *A. quandang* (on *Acacia* sp.) 'are greedily eaten by camels†, and so are, in all probability,

equally attractive to vegetivorous (sic) marsupials'. The footnote reads: '† Camels will browse upon the parasites and leave the hosts quite untouched, although the latter are themselves excellent food.' Blakely (1922) listed five other reports of livestock browsing on mistletoes in temperate and arid areas, and May (1941) received 32 reports from throughout NSW of livestock eating mistletoe foliage. Barlow and Wiens (1977) documented all the literature reports of camels, goats, sheep and cattle feeding on mistletoe foliage.

Mistletoes and fire
May (1941) suggested that fire suppression in agricultural districts since European settlement had permitted fire-sensitive mistletoe populations to increase:

On uncleared land a fire tends to kill the Mistletoes while eucalypts on which they grow are able to regenerate. On land which has been cleared of undergrowth or which is more or less protected by man, bushfires either do not occur, or, on the rare occasions when they do, are very severe and destroy all the timber. Thus the activities of man result in fire not freeing the host plants of their parasites. This point is worthy of notice, and is perhaps connected with the recent increase in the amounts of Mistletoe.

A note in the *Australian Timber Journal* reports the use of 'weed burners' to kill mistletoe in South Australia (Anon. 1949):

*Our South Australian correspondent writes that, following further publicity given to the depredations of mistletoe, it has been announced that weed burners - like large blowlamps, and an improvement on the flame thrower - had been used to destroy mistletoe on low timber on Yorke Peninsula, with excellent results. The Government Weed Advisor (Mr H.E. Orchard) said the burners threw a 2 ft. 6 in. flame at a heat of 2,000 degrees Fahrenheit, which instantly seared the mistletoe [*A. miquelii* or *L. exocarpi*]. The parasite was very susceptible to heat, and could be destroyed without affecting the trees, many of which had made strong regrowth since their treatment. The only disadvantage of the weed burners was that they were useless against mistletoe at the tops of high and inaccessible trees.*

Coleman (1949) reported:

It was recently reported (18.5.49) that flame throwers are to be used this winter against the mistletoe which is slowly killing tens of thousands of eucalypts and other trees in South Australia. Prof. J.B. Cleland stated that, undoubtedly, the chief cause of the spread of the pest was the more effective control of bushfires. Mistletoe was sensitive to fire. When a bushfire swept through gum country it cleaned out the parasite, but left the gums to grow vigorously again.

Cleland (1940) observed that 36 mistletoes on a South Australian Blue Gum *Eucalyptus leucoxylon* were killed by a wildfire at Belair Recreation Park near Adelaide, whereas the host resprouted. Forty years later, *A. miquelii* was again abundant on gums in Belair Recreation Park and on *E. leucoxylon* in the Clare Valley prior to the February 1983 bushfires. Most of the eucalypts but few of the mistletoes survived in burnt areas (Anon. 1993; Z. Yan 1992, *pers. comm.*). John Choate (1993, *pers. comm.* 13 April) provided the following observations about the impact of wildfire on *A. miquelii* parasitising *E. leucoxylon* at Morialta Conservation Park near Adelaide. The wildfire in April 1991 produced complete canopy scorch in all host trees and all but one mistletoe. After two years, 11 of 21 mistletoes were dead. In a nearby unburnt control plot established just after the wildfire, mistletoe numbers were the same after two years. Liddy (1982) ascribed high population densities of *Amyema cambagei* and hyperparasitic *Notothixos subaureus* in coastal *Casuarina glauca* open-forest in south-eastern Queensland to the cessation of annual burning 12 years previously.

Three recent experimental studies of the response of mistletoes to individual burning have been conducted. Reid and Yan (1992 *unpubl.*) burnt 24 plants of *A. miquelii* and *A. pendula* with a portable kerosene flamethrower. Complete canopy scorch of 21 plants resulted in the death of all but one. A small portion (2-5%) of the remaining three mistletoes was not scorched and the three were still alive two years later. Gill and Moore (1993) studied the fire response of *A. miquelii* on eucalypt hosts in Canberra, ACT. They found that bark thickness of eucalypt host branches just proximal to the haustorium was greater than the bark thickness of the mistletoe haustorium. Burning by passing a kerosene-fuelled flamethrower across the entire mistletoe canopy for 13-68 s (depending on mistletoe size) killed nine of 12 mistletoes, whereas directed burning of the haustorium from below for 11-40 s killed seven of 12 plants. After burning, regrowth from surviving mistletoes took place from buds in the haustorium as well as from the axils of leaves and branches. Subsequent experiments with a gas-fuelled flame directed at the haustorium resulted in complete kill of 10 mistletoes which were each burnt for the length of time in seconds equivalent to four times the girth of the eucalypt branch immediately proximal to the haustorium measured in centimetres. The same treatment only killed four of 10 plants burnt for twice the girth measurement.

Kelly *et al.* (1997) conducted experimental burning studies of *A. miquelii* and *A. pendula* near Armidale, NSW. After two years, all control plants were still alive but 17% of burnt *A. miquelii* and 50% of burnt *A. pendula* were killed by passage of the flame of a kerosene-fuelled flamethrower across the foliage. Small *A. miquelii* were more susceptible to fire (70% mortality) than medium-sized and large plants (15% mortality). Mistletoes that survived burning had not recovered their pre-treatment canopy dimensions after two years, and were slower to resprout than mistletoes that were simply pruned of all their leaves. Burnt survivors also resprouted from thicker branches than defoliated mistletoes.

The role of arboreal marsupials and fire in containing mistletoe populations

From the evidence reviewed above, it is clear that the foliage or fruit and flowers of some Australian mistletoes are a preferred part of the diet of some populations of arboreal marsupial, and that some mistletoe species are fire-sensitive. The interactions are likely to be complex, however. In the case of mistletoes and arboreal marsupials, the generalisation that 'arboreal marsupials prefer mistletoes' is incorrect because many Australian dietary studies of possums, koalas and gliders have failed to

detect mistletoe in the diet. Although this is likely to be due to an absence of mistletoes in many study sites (perhaps due to the efficacy of healthy populations of arboreal marsupial to suppress or eliminate mistletoe populations), it is doubtless also due to the fact that some local populations of arboreal marsupial prefer not to eat local mistletoes. Although Porter (1990) found that Common Ringtail Possums markedly biased their feeding towards the foliage of *Muellerina eucalyptoides* and, to a lesser extent, *Amyema pendula*, in northern NSW, Thomson and Owen (1964) recorded no feeding on *A. pendula* in southern Victoria despite the fact that their study animals built dreys on *A. pendula* haustoria. Similarly, Young (1937) and Choate *et al.* (1987) carefully documented preferential feeding by Common Brushtail Possums on mistletoe foliage rather than host foliage, whereas Atsatt (1983) found the reverse. May (1941) cited a correspondent from Koala Park, near Sydney: 'At Koala Park, where bears are afforded as much liberty as possible, and where Mistletoe [*Muellerina eucalyptoides*] is prevalent, not a single instance of bears or opossums eating such leaves has been observed.' Since the relative palatability of a particular foliage to a herbivore is dependent on the palatability of the surrounding vegetation, the outcome of mistletoe-possum interactions is partly dependent on the availability of alternative food sources. The quality of both mistletoe and alternative plant food sources is likely to vary throughout the year, as will the dietary requirements of arboreal herbivores. In short, whether an arboreal marsupial eats a mistletoe is dependent on the species of mistletoe, the species of marsupial, the particular local populations involved, the season, and the composition and abundance of alternative food sources.

It might be argued that arboreal marsupials increased in abundance in south-eastern Australia after removal of Aboriginal hunting pressure during the last century (e.g. Johnson and Jarman 1976), and that arboreal marsupials were maintained at too low a level by Aboriginal hunting to affect mistletoe abundance in pre-European landscapes. In this context, it should be noted that mistletoes were locally abundant in

parts of both the temperate and arid zone at the time of European settlement (Moore 1899; Coleman 1949; White 1913). While there is evidence of population explosions in a range of indigenous and exotic mammals following pastoral settlement and its decimation of the Aboriginal and Dingo *Canis familiaris dingo* populations (Johnson and Jarman 1976; Jarman 1994), the local and regional extinctions and continuing declines in distribution and abundance of arboreal marsupials this century (Young 1937; Anon. 1945; Evans 1992; Hobbs *et al.* 1994; Callister and Williams 1995) testify to the comparative severity of the impacts of European settlement. Aboriginals may have exerted some control of mistletoe populations as well, as the fruits were eaten by people throughout the continent (Palmer 1883; Turner 1904) and still are in central Australia (L. Baker 1995, *pers. comm.*).

In the case of fire and mistletoes, the variability in the response of mistletoes to burning is due to the survival ability of the host, intensity of the fire, mistletoe bark thickness, size of mistletoe (since bark thickness is positively related to branch diameter: Gill and Moore 1993), the mistletoe's possession of epicormic buds on thicker stems, the vertical distribution of vegetation (fuel), and the height of the mistletoe above ground. Thus, in the case of a fire-sensitive mistletoe growing on a fire-tolerant host such as a woodland eucalypt (e.g. a 'sprouter'), most mistletoes might be expected to survive a low intensity burn, especially large plants high in the canopy, whereas most or all will die in a high intensity fire. The patchiness of many wildfires means that stands of timber or scattered trees and their mistletoe parasites may often be spared despite the fact that a majority of the area is burnt by intense fire.

Fires and possums are capable of exerting considerable control on mistletoe numbers or fecundity, at least in certain times and places. Particularly relevant is the evidence of chronic suppression of reproduction or vigour in the case of possum browsing (Young 1937; Anon. 1945; Porter 1990), the occasional elimination of local populations of mistletoe by arboreal marsupials (Young 1937; Campbell 1948), the high mortality after intense fires (Cleland 1940)

and the slow vegetative recovery of surviving mistletoes after less intense fires (Kelly *et al.* 1997). The hypotheses that fire and browsing by arboreal marsupials are capable of acting as natural control agents of mistletoe population density are thus supported by the data. Not surprisingly, where the densities of arboreal marsupials and the frequency of wildfire and prescribed fire remain high, such as in the high rainfall, timber production forests of southern and eastern Australia, mistletoes are rarely a management problem (McKinnell *et al.* 1991). However, the agricultural districts are characterised by declining abundances and local extinctions of arboreal marsupials (Hobbs *et al.* 1994) and fire suppression, and mistletoe infestation of remnant trees and the potential for mistletoe infestation of tree plantings concern rural communities (Reid 1995).

The impact of arboreal marsupials and fire on mistletoe populations may help explain the patterns of mistletoe abundance in present day landscapes. In agricultural districts in south-eastern Australia, many writers have described the tendency for mistletoe infestations to occur along roadsides, the edges of forest blocks and woodland remnants, in thinned timber, small stands, and in isolated trees and scattered trees close to larger stands (e.g. May 1941; Hartigan 1960; Calder *et al.* 1979; Lamont and Southall 1982). These are precisely the areas where arboreal marsupials and canopy fires are least likely to reach because of the break in canopy, the tendency to use roads and edges for backburning when fighting wildfire, and perhaps the reluctance of arboreal marsupials to feed in edge or isolated trees due to greater risk of predation.

The long history of evolutionary interaction between mistletoes and arboreal marsupials in Australia has resulted in host mimicry in leaf shape in many species of Australian mistletoe (Barlow and Wiens 1977; Barlow 1981, 1986). It may have other legacies. The leaves of *Amyema* species are high in tannins (Atsatt 1983; J. Foulkes 1996, *pers. comm.* 21 September), presumably to deter herbivory by arboreal marsupials. The typical pendulous habit of eucalypt-parasitising mistletoes (seen in most populations of *Amyema miquelii, A. pendula* and *A. bifurcatum* and some populations of *Muellerina eucalyptoides*) may also be adaptive, to minimise loss of mistletoe foliage, flowers and fruits to arboreal marsupials: animals weighing between 1-9 kg are unlikely to venture too far down thin brittle mistletoe branches in long pendulous canopies.

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    A guide to the ancient flora of Victoria, with notes on localities and fossil collecting.

A Field Companion to Australian Fungi'. (B. Fuhrer) $19.95
    A reprint of the earlier book with additional photographs and incorporating
    name changes.

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    144 magnificent illustrations of the spectacular flora of this region.

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'Roadside Geology, Melbourne to Ballarat'. (ed. N.Schleiger) $18.00
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Contact: Alan Parkin
Book Sales Officer 9850 2617 (H), 9565 4974 (B)

Muellerina and Other Mistletoes
of Southern Queensland

G. R. Scott[1]

The scenario for mistletoes in southern Queensland is illustrated in Table 1.

There are now 86 named Australian species of mistletoe (Barlow 1984). Of these, 37% occur in or within 200 km of Toowoomba in southern Queensland and the far north of New South Wales, and 50% within 600 km (Table 2). This diversity of species is a direct reflection of the number of different climatic regions and habitats, and hence the variety of hosts, within these distances from the top of the Great Dividing Range in South-east Queensland. The area is not necessarily one where much speciation has occurred in general, but one genus, *Muellerina* Tiegheim, has apparently evolved more or less within this region.

Muellerina species are centred on the McPherson Range, which forms the eastern end of the border between Queensland and New South Wales. Only two of the four listed species of *Muellerina* extend any great distance beyond that region; *M. eucalyptoides* (Fig. 1) and *M. celastroides* have both spread southwards along the coast and coastal ranges, the first as far as South Australia, the latter to eastern Victoria; both have also spread some 300 km north of Brisbane. Hybrids between *M. eucalyptoides* and *M. celastroides* are also known; in southern Queensland these live predominantly in exotic trees such as the Pepper Tree *Schinus molle*, London Plane *Platanus* sp, Norfolk Island Hibiscus *Lagunaria patersoni* and Camphor Laurel *Cinnamomum camphora*.

In southern Queensland, *M. eucalyptoides* grows only on eucalypts but in Victoria it occurs also on a number of exotic hosts. It also assumes a very different growth habit in Victoria even when growing on its normal eucalypt hosts, being very bushy compared with northern specimens, which are extremely pendulous (*pers. obs.*).

The third species, *M. myrtifolia* lives only in the rainforests of the McPherson Range and, in the area from which Barlow collected it around Killarney/Acacia Ridge (Barlow 1962), is fast becoming a rare plant owing to land clearing. It grows on *Pandorea* and *Parsonsia* vines and occasionally on the shrubs these vines grow over.

The fourth species, *M. bidwillii* (Fig. 2) occurs inland in Cypress Pine country and

Table 1. List of genera of Mistletoes found in, or near, Toowoomba.
Key: A = number of species in the genus; B = number of these species found in Southern Queensland.

Species	A	B
Loranthaceae		
Amyema	36	11
Benthamina	1	1
Dendrophthoe	6	2
Diplatia	3	2
Lysiana	8	3
Muellerina	4	4
Amylotheca	2	1
Viscaceae		
Viscum	4	3
Notothixos	4	3
Korthalsella	6	2

[1] 1/8 Spies Court, Toowoomba, Queensland 4350.
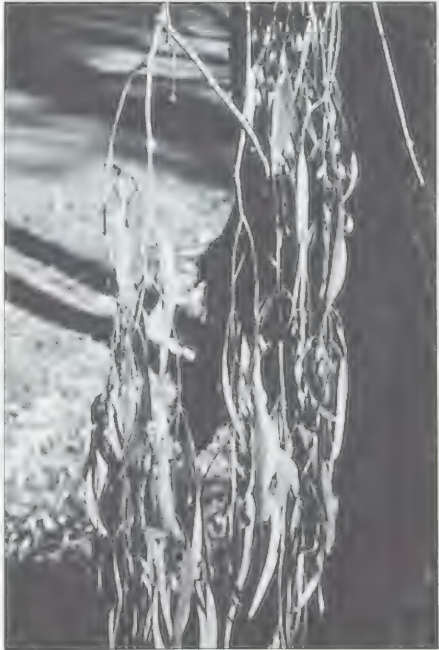
Fig. 1. Creeping Mistletoe *Muellerina eucalyptoides* growing on Sydney Blue Gum *Eucalyptus saligna* showing the usual pendulous habit of this species in NSW and Qld.

Table 2. Mistletoe species list for south-east Queensland.
Key: * – occurences far to the east of the region recorded by Barlow (1966); [gs] = genus or generic group specific; [ss] = species specific; [ls] = loranth specific; [ms] = mangrove specific; [T] = in Toowoomba; [+] = distinct leaf form normal in far western Queensland (Barlow 1966).

Species within 200 km of Toowoomba

Loranthaceae	*Amyema bifurcata*[T gs]	*Dendrophthoe glabrescens*[T gs]
Amylotheca dictyophleba[T]	*A. cambagei*[T gs]	*D. vitellina*[T]
Benthamina alyxifolia	*A. linophylla*[ss]	
	A. conspicua[ss]	**Viscaceae**
Lysiana exocarpi subsp. *tenuis*[gs]	*A. gaudichaudi*[gs]	*Viscum articulatum*[T ls]
L. exocarpi subsp. *exocarpi*[T]	*A. lucasi*[* T gs]	*V. whitei*[ls]
L. subfalcata	*A. quandang*[T gs]	*V. bancroftii*[ls]
	A. maidenii[gs]	
Muellerina eucalyptoides[T]	*A. miraculosa*	*Notothixos incanus*[gs]
M. celastroides	*A. congener*[T gs]	*N. subaureus*[T ls]
M. celastroides? subsp. *araucariae*[ss]	*A. miquelii*[T gs]	*N. cornifolius*[T gs]
M. bidwillii[gs]	*A. pendula*[T gs]	
M. myrtifolia		*Korthalsella rubra ss eijericola*[gs]
M. euc. x *celastr.* hybrid[T]	*Diplatia furcata*[gs]	*K. breviarticulatum*[T gs]
	D. grandibracteata[* gs]	

Species between 200 and 600 km of Toowoomba

Loranthaceae	*L. maritima*[ms]	*Diplatia grandibracteata*[gs]
Lysiana murrayi[gs]	*L. subfalcata*	
L. filifolia[gs]		**Viscaceae**
L. exocarpi subsp. *diamantinensis*[+]	*Amyema mackayense*[ms]	*Viscum* spp. as above
L. linearifolia	*A. lucasi*[gs]	

Fig. 2. Casuarina Mistletoe *Muellerina bidwillii*, Warrabah National Park, NSW.
Photo by Ron Fletcher.

extends southwards to the ACT; it grows exclusively on *Callitris*. To date it is the only native mistletoe listed as living on a gymnosperm, but I suggest there is a fifth species of *Muellerina*, specific to the Hoop Pine *Araucaria cunninghamii.*

The specimens (Fig. 3) which I found growing in Hoop Pine some ten years ago key out to *M. celastroides* on the structure of the inflorescence but there the resemblance ends. Whereas *M. celastroides* (Fig. 4) has large (<4 cm), pale cream flowers flushed with pink, the Hoop Pine specimen has small (1.5 cm) bright pink to red flowers. The leaves, likewise, are much reduced in size and narrower than in *M. celastroides*. If this is not a new species, then I suggest that it is an excellent example of modification in line with Dr Peter Atsatt's theory that 'mimicry' is the result of the action of the hosts' growth hormones on the developing mistletoes.

The good thing about this case is that, if it is a case of mimicry, we have both the 'original' species and the 'modified' species. The bad thing is that I have only found two occurrences of the Hoop Pine species. One, near Killarney, is intact but it is only in one tree. Fortunately, there are now several new plants of the mistletoe growing in the same tree. Equally fortunately, it is growing on

Fig. 3. Flowers of *Muellerina celastroides* var. *'araucariae'* growing on Hoop Pine *Araucaria cunninghamii* in south-east Queensland.

Fig. 4. Flowers of Coast Mistletoe *Muellerina celastroides* growing on Coastal Banksia *Banksia integrifolia*.

the property of some very conservation-minded people and they have promised it will not be cut out.

The other occurrence, which was of a large number of specimens growing in a stand of Hoop Pine on the road up to O'Reilly's Guest house - 100 km away as the birds fly - has since been cut out. It is important, therefore, that further occurrences of these plants growing in Hoop Pine are found and their occurrence registered.

Since I started collecting mistletoes about 1980, I have found some species in locations much further east than given in the literature. This in part reflects the patchy nature of collecting. The disjunct distribution of these species gives rise to interesting speculations about the cause of the large gaps between the sites. Is it that the species and their hosts were at one time far more continuously distributed and have suffered extinction in some areas? Or are the disjunctions due to the behaviour of the various bird species involved in their distribution? We certainly need to know more about the behaviour, especially the flight distances, of the fruit eating birds involved.

As an example of such a disjunction I cite *Amyema lucasi*, which grows on species of *Flindersia* e.g. Leopard Wood *F. maculata*. It is normally found only beyond Charleville, several hundred kilometres to the west. It is also growing near Toowoomba on

F. collina at Gowrie Little Plains and Flagstone Creek. I have searched in vain for other specimens of *F. collina* west of the eastern Downs. The Crow Ash *F. australis* is quite common in the district but appears not to carry any mistletoes at all.

Another disjunct species location is for *Diplatia grandibracteata*, an outlier of which was found in the Lake Broadwater district about 30 km south of Dalby, some 300 km east of its normal regions. Such disjunct distributions are not solely an eastern phenomenon. When in Western Australia, I found one species, previously thought to have a very restricted distribution in Central Australia, in Willuna cemetery in the northern goldfields.

Whilst the Mistletoe Bird, a relative newcomer to this continent, may be very important in maintaining populations of mistletoes within a restricted area, we may have to give credit to other fruit-eating birds with longer digestion times and longer flying distances for the wider distribution of mistletoe species across the continent.

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I have been unable to obtain the later reference - Barlow, B.A. (1992). *Blumea* **36**, 293-381, who refers to two additional species.

Fungal Pathogens of Mistletoes in Victoria

Vyrna Beilharz[1]

In nature, it may be said, no niche remains unexploited. It is hardly surprising, then, that just as mistletoes exploit the niches provided by their tree hosts, they in turn provide suitable habitats for a range of fungal pathogens. Three highly specialised foliar pathogens of mistletoe are of particular interest in Victoria; two, perhaps, for their rarity and one for its abundance. Each needs to grow on living host tissue for at least most of its life cycle, and each has evolved a different way of co-existing with its host.

From the historical viewpoint, the mistletoe rust caused by the fungus *Puccinia loranthicola* McAlpine is the most interesting of these pathogens. Only two herbarium specimens are known in Australia, both collected by Robinson in 1905 in the Murramurrangbong Ranges, the old name for the ranges separating the Kiewa and Yackandandah valleys, centred on Big Ben, Gippsland. The host is recorded as *Loranthus celastroides* Sieb. (McAlpine, 1906), which is now *Muellerina celastroides* (Sieber ex Schult. & Schult. f. Tiegh. 1895).

Rust fungi are unique in that they may form as many as five different spore types in their complete life cycle, each spore type serving a different function. Such rusts frequently require the presence of two hosts, often completely unrelated (for example, a monocot and a dicot) for the development of the five successively produced spore types. Like many rust fungi, however, *P. loranthicola* has a reduced life cycle, producing only three types of spore in conspicuous, clustered pustules containing powdery masses of either orange, brown or yellow spores. As in all rust fungi, the hyphae (fungal threads) of *P. loranthicola* ramify through the host tissue, packing the intercellular spaces but not directly penetrating the cells. Although nutrients can be absorbed directly by hyphae, the rust fungi draw nutrients from the host cells by more delicate means; very fine infection pegs pass from the hyphae through the cell walls, where they expand

to form small, single-celled, often coiled or branched, haustoria (Fig. 1) which absorb nutrients across the plasma membrane without damaging it. Rust fungi are able to influence the physiology of the infected host tissue so that more nutrients than usual are directed to the site of infection; in fact, the infected areas often remain green longer than other parts of the leaf.

The most common fungal pathogen of mistletoes in Victoria is *Cercospora loranthi* McAlpine, the cause of Brown Scab disease of numerous species of *Amyema* (*A. linophylla, A. miquelii, A. pendula, A. preissii* and *A. quandang*) as well as *Muellerina eucalyptoides*. Infected leaves (and also stems, in the case of *A. preissii*) can be peppered with numerous small (to 2 mm diam.), raised reddish-brown spots (Figs. 2, 3). As in the rust fungi, the hyphae of *C. loranthi* are intercellular, but they absorb nutrients directly through the host cell walls, and do not form haustoria. It is significant that this fungus, with its less specialised relationship with its host, can be grown in artificial culture, while the rusts and powdery mildews cannot. Nevertheless, as soon as it invades the leaf tissue *C. loranthi* induces the host cells to multiply, presumably securing for itself an increased supply of nutrients. *Cercospora loranthi* produces asexual spores on specialised spore-bearing hyphae (conidiophores) which initially emerge through the stomata and later erupt in large masses through the leaf surface (Fig. 3, 4).
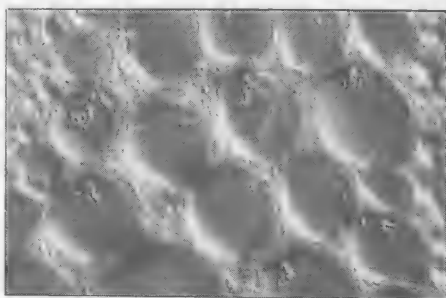
Fig. 1. Intercellular hyphae packed between host cells, and fragile haustoria within the cells (in the rust *Puccinia malvacearum* on a stem of *Malva* sp.) (x240).

[1]382 Drummond Street, Carlton, Victoria 3053

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Fig. 2. Leaf of *Amyema* sp. with brown scab disease (x2).
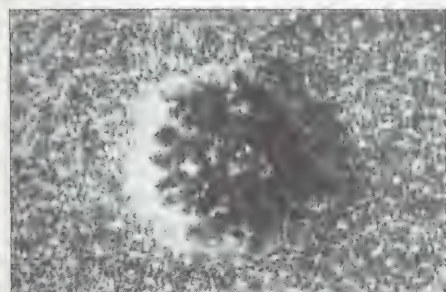
Fig. 3. Brown scab, magnified, with sporulation on surface (x15).
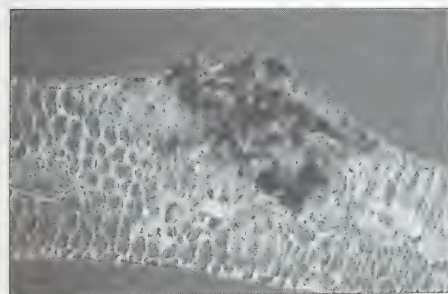
Fig. 4. Section through a small, developing brown scab with sheets of hyphae visible in the host tissue, and elongated spores being produced on the surface (x30).

The third pathogen causes powdery mildew on mistletoe leaves (*Amyema* spp.) Few collections have been made, and the precise identity of the fungus has not been determined, partly because, in common with the majority of powdery mildew fungi in Australia, it does not produce the sexual fruiting bodies which are the basis of classification in the group. It is not known whether the fungus is endemic or a cross-infection from another, unrelated host.

With few exceptions, powdery mildew fungi grow and reproduce entirely on the leaf surface (also at times on stems, flowers etc), the colourless hyphae and spore masses causing the whitish bloom familiar to many home gardeners. As in the rust fungi, nutrients are extracted from the host cells by small haustoria, but in this case, only the epidermal cells are affected, as the penetration pegs develop from the hyphae growing on the plant surface. Powdery mildew fungi, like rust fungi, can survive only in association with living host tissue, so this relatively non-disruptive mode of nutrition is central to their survival.

To assist research on these diseases, any collections of powdery mildew or rust on mistletoe would be welcomed by:

Mr Ian Pascoe,
Institute for Horticultural Development,
621 Burwood highway, Knoxfield (postal address: Private Bag 15, South-Eastern Mail Centre, Victoria 3176).

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Drooping Mistletoe *Amyema pendula*, Kinchega NP, NSW. Photo R.J. Fletcher.

Those Amazing Mistletoe Plants

The very beginnings of these plants are sheer magic and its survival in the early stages is an incredible story. This amazing plant occurs in mangroves, jungles, deserts, dry and wet sclerophyll forests, mallee, heathland etc. and it is time its public image was lifted.

Mistletoe plants were long recognised by Koori people as a useful food source. Especially the sticky fruits of the *Amyema* species which were eaten raw. The pulp is sweet and the leaves were also used for medicinal purposes. In more recent times a European Mistletoe derivative marketed under the name of Iscador is being used in England and Australia. It is believed that it **may** build up the immune system of people suffering from certain forms of cancer.

I feel that not enough is known about many of our plants in Australia and if we think about the medicines obtained and yet to be discovered in our diminishing rainforests world wide - who knows what research into Mistletoes would reveal.

Fires lit by Aboriginal people all over this country would have effected some control over this fire-sensitive plant. On the other hand, an increase in the quantity of Mistletoe has probably occurred with the altered landscape and fire regime that developed with European settlement, and as a result Mistletoe is now considered by some to be a problem plant. .

The majority of people I speak to, talk with concern about its required removal and I have witnessed large-scale vandalism in bushland reserves and on private property. Trees with only minor outbreaks of Mistletoe have suffered rigorous pruning and complete removal of the Mistletoe plant. This with little regard or knowledge for the food and shelter that this marvellous plant provides. According to the literature a tree needs to be infected by at least 50% to be in danger of becoming moisture stressed and possibly dying. Most people seem to lose sight of the fact that this green semi-parasitic plant does photosynthesise.

Uses

The twelve species of Mistletoe we have in Victoria provide nectar for animals over a long period: for example the flowering season of *Amyema pendula* sometimes stretches from May until the following summer. The flowering of various Mistletoe species covers most months of the year and would be vital for animals in search of nectar in winter when little else may be flowering. For example, Brushtail Possums and Yellow-bellied Gliders have been recorded feeding on *Amyema* flowers and if this is so why not Sugar Gliders, Pygmy Possums and Feathertail Gliders?

Butterflies, Moths, Ants, Jewel Beetles, Longicorn Beetles, Borers, native and introduced bees as well as the introduced Honeybee have all been recorded living on Mistletoe.

The larvae of moths and butterflies now numbering 30 recorded species depend on the leaves for food. 'Thirty three bird species have been recorded feeding on Mistletoe berries but the digestive process does not aid in Mistletoe dispersal' (Stephen Platt).

I would expect that Lorikeets would relish the nectar in winter when little else is flowering, perhaps attracted to the tree in the first instance by the flowers on the Eucalypts and then discovering the Mistletoe flowers.

We need to enlist the aid of landowners to help us record what birds feed on nectar of Mistletoe, especially through the Land For Wildlife scheme where the educational newsletter already does a magnificent job of passing on this type of information. Stephen Platt LFW. note 26, remarks that 'Forty one species of birds, mainly Honeyeaters use Mistletoe flowers'.

One could argue that trees with flowering Mistletoe may in fact attract Honeyeaters. A tree might be advantaged by having Mistletoe in it to attract Honeyeaters. It is said that 75% of a Honeyeater's diet consists of insects. Consequently the tree could benefit while feeding and foraging is taking place, and the pollination of Eucalypts and Mistletoe is facilitated, whilst also keeping insects under control.

A lot of animals use the bushy, thick and pendulous leaf masses on mature plants for shelter. I have observed many birds' nests and possums' dreys hidden in their voluminous foliage and seen many birds feeding and sheltering in Mistletoe plants. In fact, it has become an interest of mine that

when I discover Mistletoe I search for signs of its many uses by our local fauna.

The large colonies of Imperial White Butterflies alone must be an important food source. (With two generations per year often containing sixty or seventy larvae to one web this must surely be one of the natural controls of Mistletoe). Wood White, Common Jezabel and Imperial White Butterflies, both larvae and adults, may contribute considerably to the food source of many animals especially birds: Magpies, Butcherbirds, Currawongs and Kookaburras.

Last year I rescued approximately 40 Imperial White Butterfly larvae and pupae cases from the ground where they lay. Some were crushed and already dead. The large branch under which they lay had been cut down from a Eucalypt which had been sawn off and left where it fell. Perhaps the property owner mistook the dark larvae for sawfly larvae. This animal also suffers from a poor public image and again without just cause. But both Mistletoe and the insects obviously were not wanted and both were **almost** destroyed. I did manage to raise and save more than half of the butterflies, which were released into local bushland within metres of the site where I found them.

Land Clearance

Over the years I have observed heavier infestations on solitary trees in partially cleared land, and also a greater incidence of Mistletoe along roadsides. Opening the canopy and letting in more light may favour the plant and attract the Mistletoe Bird. Also, roadsides are often flight paths for birds that spread the seed i.e. Mistletoe Birds and Painted Honeyeaters.

To test the roadside theory I have on many occasions explored further into good quality bushland **directly** behind heavy infestations and on all occasions fewer occurrences of the plant was observed.

Over a period of nearly two decades of fascination with, and observation of, this plant I have come to this conclusion, that we should be providing educational leaflets for property owners (urban and rural) which contain sensible guidelines on how to appreciate and/or control Mistletoe.

As naturalists and scientists we need to inform the media in its many forms that this plant is a natural and fascinating component of our native flora and vital to the lives of many animals including birds. It is an important source of food and shelter and essential for the survival of several species of some of our most beautiful butterflies.

Apart from all those reasons it is a plant that we could learn a lot more about so that we can support and nurture its growth and at the same time develop **sensible** management strategies.

The following list of strategies are not listed in order or importance, but just as they came to mind.

1. Landowners need to have access to information that educates them about the biological control of Mistletoe **that already naturally occurs** i.e. fungal infection, insect predation and to a lesser extent, fire.
2. Information should be accurate on how much Mistletoe a tree can tolerate, and if Mistletoe needs to be removed at all.
3. We must enlist the aid of farmers, rangers, land managers, councils, etc. to help provide data on the Mistletoe community. A Mistletoe observation form would be a great way to start recording, and one is available from the author. This form could be adapted to cover a wider area and to include more details. A reporting form such as this could be circulated to the Bird Observers Club, all Field Naturalists Clubs and the Land For Wildlife property owners - the data collected would be invaluable.
4. To continue and enlarge on strategy 3, all the animals that make up the Mistletoe community should be recorded. We need to balance the scale against indiscriminate and random removal of Mistletoe.
5. I have a question for you - Why should it be illegal to collect seeds without a collector's license - or collect any plant material of any kind without a license. Why do we have laws to proctect over-collection of marine and rock pool animals? And yet there does not appear to me to be a law to protect the Mistletoe **Community**. Mistletoe is often removed without any thought of the consequences that involve other animals.
6. Councils, landowners (urban and rural) and all government departments responsible for making decisions on land management **need information now.**

Hopefully after this forum has finished and with all the information gleaned from our speakers today we can take the first steps to drafting some recommendations.

To me this is the vital and important outcome that should result from this 3-day 1996 forum, and I look forward to the day when Mistletoes are valued for the unique niche they occupy in the environment.

Cecily Falkingham
27 Chippewa Ave, Mitcham, Victoria 3132

Mammals and Mistletoe

There are about 70 species of mistletoe found in Australia. A recent forum on mistletoe, organised by Malcolm Calder and Ken Simpson for The Field Naturalists Club of Victoria, brought mistletoe enthusiasts and specialists together for a day-long workshop, at which we mistletoe tyros learned what makes these plants tick. This was followed a couple of months later by a full-day symposium and then a most enjoyable field day in the You Yangs and Anakie area, south-west of Melbourne.

Among the ecological attributes of mistletoe were listed the wide range of birds and invertebrates that depend on it for either food or shelter, or both. However, apart from some brief comments about Flying Foxes feeding on mistletoe, the occasional construction of dreys in the sheltering mass of a mistletoe plant by Common Ringtail Possums and the debated role of the Common Brushtail Possum controlling the growth of mistletoe by browsing, there was little I could find in the literature or at the Symposium to link mammals with this often abundant food and shelter source.

So, a request: if you have reliable records of any mammals in Australia using mistletoe, I would like to hear from you. I would, of course, like to have the species of mammal, mistletoe and host tree recorded, but I know that mistletoes are not always that easy to identify, even if you think you know what they are!

I have prepared a simple report sheet - see the easy to photocopy example below - and I would be happy to receive any observations.

John Seebeck

Mammal Species	
Number and sex, if determined	
Mistletoe Species	
Host-plant Species	
Date	
Locality	
Was the mammal **(a) Feeding:** on flowers; on fruit; on leaves; on others, **e.g., invertebrates**	
(b) Nesting	
(c) Other?	
Please return to	John Seebeck, Flora and Fauna Branch NRE, PO Box 41, East Melbourne 3002: Ph. 03 9412 4298; Fax 03 9412 4586; email j.seebeck@dce.vic.gov.au

From our Naturalist in Residence, Ian Endersby

Webspinner

There is story that the Emu and the Kangaroo were chosen to support the Australian Coat of Arms because neither of those animals can walk backwards. In fact it is rare to see any animal walking backwards. Horses can, otherwise our forebears could never have harnessed the jinker, and cows could never have moved out of the bail after milking. However, if you put an obstacle in the path of a bumbling beetle it will turn aside rather than reverse.

Except for mosquitoes and silverfish, which attack me and my books respectively, insects and spiders are welcome in our house, although White-tailed and Wolf Spiders are carefully shepherded outside in case the stories about their dirty fangs are true. One species that runs backwards turned out to be of particular interest.

On an August afternoon a black insect about a centimetre long and superficially resembling a small earwig was found on a tiled floor inside our house. When confronted with a specimen tube it ran backwards, very fast and in a straight line. Under the stereo microscope it was seen to have biting mouthparts, beaded antennae, no wings, segmented body, left cercus curved, right cercus straight, first segment of forelegs enlarged and last segment of hindlegs enlarged. Kept in captivity in a large jar containing damp compost it built a tubular web in the leaf matter. Exactly a month later another male was found wandering in the same place as the first.

The bulbous fore tarsi are packed with silk glands and make the insect instantly recognised as being one of the Embioptera, the Web-spinners. Australia is home to three families of these rarely seen insects: Notoligotomidae, Australembiidae and Oligotomidae. Males can be distinguished by the form of their cerci and my specimen was one of the Australembiidae, a family known only from eastern mainland Australia and Tasmania. It was very like the photograph of *Metoligotoma reducta* species complex in CSIRO's Insects of

Australia. Because they spend their lives in silken galleries, they are an insect which is rarely seen. Wandering males in search of mates are, therefore, the most commonly reported.

Living in a gallery protects the webspinner from enemies and also provides a microclimate that reduces the likelihood of desiccation in hot areas or ameliorates other environmental dangers. They spend much of their time extending their galleries to new food sources of vegetable matter: bark; leaves; mosses and lichens.

Almost all of the features noted under the microscope are adaptations to their peculiar way of life. The tarsal glands provide the silk to make the tubes which the webspinner does by slowly rotating its body as it weaves. To keep the diameter of the tube constant and the correct diameter it has sensitive hairs on its body which act as a gauge. My initial observation was of an insect that could run backwards and this is another adaptation to life in a tube. Enlarged femora of the hind legs are due to the tibial muscles which allow efficient running particularly to escape enemies such as ants. In addition, the caudal cerci are highly sensitive and act as tactile eyes or 'rear-vision mirrors'. The supple body, short legs and aptery would also seem to be adaptations to reverse locomotion in narrow tunnels.

Australia has about 65 species of the Embioptera most of them tropical and all of them cryptic, so I have been privileged to have the opportunity to view one so closely.

Ian Endersby
56 Looker Road, Montmorency, Victoria 3094.

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The
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Congratulations John Koehn
1997 Gold Banksia Award Winner

John Koehn had a very successful evening at the recent 1997 Banksia Environmental Awards. He was a finalist in the Flora and Fauna Conservation Section. won the Catchment Management and Inland Waterways Section and was awarded the top prize, the Gold Banksia Award.

The Banksia Environment Foundation Inc. was established in 1989 to encourage and acknowledge those who applied their imagination to solving problems in the environment. The Banksia Awards are recognised as one of the most prestigious environmental awards made in Australia.

John Koehn has made an outstanding contribution to the conservation of Australian native freshwater fish. Special mention should be made of his work in the fish radio tracking project which aims to determine the habitat requirements and movement of Murray Cod, Trout Cod, Golden Perch, Silver Perch and Carp. The successful development of techniques for radio tracking of fish under Australian river conditions has revolutionised the study of large fish species in this country.

This project has enormous community support from angling organisations, conservation and water industry groups as well as the general public. The project newsletter CODWATCH has a circulation of 15,000 copies per issue.

John Koehn is Principal Scientist, Freshwater and Ecology Division, Marine and Freshwater Resources Institute, 123 Brown St, Heidelberg, Victoria 3084.

The Field Naturalists Club of Victoria congratulates
John on winning the 1997 Gold Banksia Award.

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Editors: Ed and Pat Grey

Cover: A juvenile Alpine She-oak Skink *Cyclodomorphus praealtus* captured using
           Schulz Reptile Trap (see p 176). Photo courtesy D. Heinze.

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A Checklist of Bryophytes for Carlisle State Park

D.A. Meagher[1] and T.A. Rankin[2]

Abstract
Fifty mosses and thirty-five liverworts are now known from a preliminary bryological survey of Carlisle State Park which is located in the catchment of the Gellibrand River in Western Victoria. (*The Victorian Naturalist*, **114**, 1997. 172-174).

Introduction

Carlisle State Park lies within the catchment of the Gellibrand River, north of the main Otway Range, between the townships of Carlisle River to the west and Gellibrand to the east. Although best known for its closed heathlands which support the threatened Ground Parrot *Pezoporus wallicus*, the 5680 ha Park contains a wide range of other vegetation types: heathy woodlands; dry, damp and wet forests; fern gullies; and bogs.

The vascular vegetation of the Park has been surveyed to some extent, but knowledge of the Park's non-vascular flora is sadly lacking. It is doubtful whether any bryophyte collections have been made previously in the Park, and certainly no bryological surveys in the Park have been reported to this time.

Our preliminary bryological survey, in June 1996, covered 14 sites in a wide range of vegetation types (Fig. 1). This survey is the basis for the following list of 50 mosses and 35 liverworts now known to occur in the Park. There are likely to be quite a few more species than this in the Park; the survey did not include very wet gullies where perhaps another half-dozen mosses and an equal number of other liverworts might occur. A notable basalt outcrop which supports a small copse of Swamp Gum *Eucalyptus ovata* was also inaccessible at the time of the survey, and is likely to support a typical rock outcrop aggregation of bryophytes which would not be found elsewhere in the Park.

The habitat in which several specimens were found suggests that our knowledge of the ecological requirements of bryophytes is incomplete. For example, *Frullania rostrata* has been thought to be a species of *Nothofagus* rainforest, yet at Carlisle it was found on *Acacia* in dry sclerophyll forest (and in similar habitats elsewhere

in Victoria by others). Similarly, *Chaetophyllopsis whiteleggei* is generally considered to be a species of dry, sandy heath or forest, but was found in dense shade on a wet, rotting limb in damp forest.

Nomenclature follows Streimann and Curnow (1989) for mosses and Scott and Bradshaw (1986) for liverworts, with the following exceptions, which follow Scott and Stone (1976) and are in common usage in Victoria: *Macromitrium tenue* is retained for *Macrocoma tenue* subsp. *tenue*, and *Sematophyllum amoenum* is retained for *Rhapidorrhynchium amoenum*.

Collections were made under permit 956/131 issued by the National Parks Service. Specimens representing all species recorded for the Park are to be lodged with the National Herbarium of Victoria.

Taxa presenting taxonomic difficulties

The checklist includes five species whose identities warrant further investigation or were difficult to determine: *Bryum ?chrysoneuron*, *Fossombronia* sp., *Kurzia uleana*, *Metzgeria ?hispidissima* and *Sphagnum australe*. The reasons are as follows:

Bryum ?chrysoneuron: The *Bryum* genus generally presents many taxonomic difficulties, and the separation of species is not always clear-cut. A specimen from a disused gravel pit certainly belongs to this genus, and is closest to *B. chrysoneuron*. However, the rhizoid gemmae are massive (up to 500 μm in diameter) and there are some differences in the leaf areolation.

Fossombronia sp.: This genus is almost impossible to identify to species level without mature capsules, which our specimen unfortunately lacks (although it does have very young capsules). A full determination must await the results of an attempt to cultivate the specimen to produce mature capsules.

Kurzia ?uleana: A single collection from A site on Tucker Orchard Road has been tentatively ascribed to *Kurzia uleana*, with a modicum of confidence. It belongs

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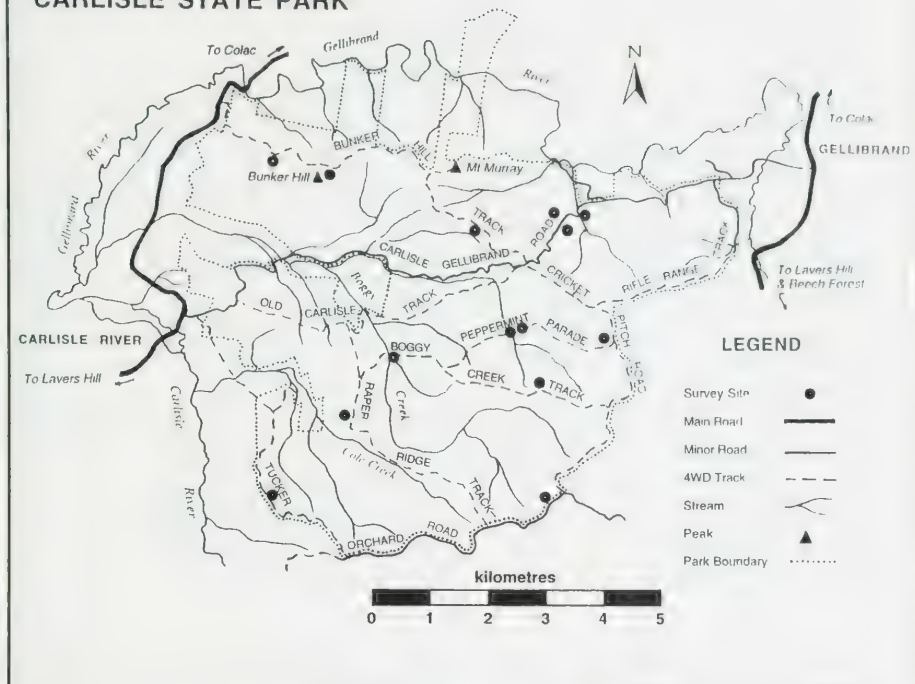
Fig. 1. Bryophyte sampling sites, Carlisle State Park, June 1996.

to a group of succubous-leaved species of *Kurzia* which are little known in Australia, and are not well covered in the literature. 'Succubous' and its opposite 'incubous', in the bryological sense, refer to the orientation of the leaf insertion on the stem. These species have been variously ascribed to the genera *Lepidozia* and *Microlepidozia*, the latter now subsumed within *Kurzia*. *K. uleana* was well described by Fulford and Taylor (1959) as *Microlepidozia uleana*, and subsequently transferred to *Kurzia* by Schuster (1980).

Metzgeria ?hispidissima: Specimens in a single collection of *Metzgeria* were spined on both dorsal and ventral surfaces of the lamina, as well as the margins. (All known Victorian species of this genus are spined only on the ventral surface and margins.) This specimen is consistent, for the most part, with the New Guinean *M. hispidissima* (Kuwahara 1966). A true determination is unlikely to be possible until the genus is reviewed.

Sphagnum australe: The several collections of a very robust *Sphagnum* from the Park match *S. australe* in all respects other than the general robustness and the size and number of pores in the branch leaf cells. The specimens in some cases are quite massive, and the stems are particularly thick. In *S. australe* the pores are reportedly small and numerous (Scott and Stone 1976), but in material from Carlisle they are medium-large and few. The branch leaves are extremely squarrose, unlike 'typical' *S. australe*, but such leaves are not unknown in that species (A. Eddy, *pers. comm.*). The specimen is thus assigned to *S. australe*, but further investigation appears prudent.

Rare or threatened species

Kurzia ?uleana: If the tentative determination is correct, this single collection represents a new record for Australia (A. Thies, G. Scott, *pers. comm.*). If not, it must still at least be a new record for Victoria; the nearest other known species is *Kurzia lateconica*, which is known

from very few collections in Queensland and NSW (A. Thies, G. Scott, *pers. comm*). The specimen was found in a disused gravel pit on the park boundary, and its status as an indigenous species thus needs to be investigated by further surveys in the area. *Kurzia uleana* is an unusual transverse to succubous-leaved species in a mostly incubous-leaved genus, and is thus of some scientific interest (Schuster 1980).

Metzgeria ?hispidissima must be considered rare in Victoria, this being the only known collection of this species (whatever its correct name) from the State, and possibly Australia. However, the identity of the specimen needs to be determined before anything further can be said about its status.

Eriopus apiculatus is considered rare in Victoria (Stone 1989). It was found at the base of a tree in its typical wet forest habitat.

Acknowledgements
Thanks are due to Dr George Scott for identifying and confirming several difficult specimens; Arthur Thies for his advice on various species; Dr Alan Eddy for advice on *Sphagnum australe*; and the National Parks Service for permission to collect in the Park.

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Personal communications
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Dr George Scott, bryologist, Fitzroy.
Arthur Thies, honorary curator of bryophytes, National Herbarium of Victoria, South Yarra.

Checklist of bryophytes for Carlisle State Park

MOSSES

Achrophyllum dentatum	Fissidens pungens	Tayloria octo-blepharum	Tortula papillosa
Acrocladium chlamydophyllum	Fissidens taylorii	Thuidium furfurosum	Wijkia extenuata
Atrichum androgynum	Fissidens tenellus	Tortula pagorum	Zygodon intermedius
Barbula calycina	Hypnodendron vitiense		
Breutelia affinis	Hypnum cupressiforme		

LIVERWORTS

MOSSES (cont.)		LIVERWORTS	
Bryum billardierei	Lembophyllum divulsum	Bazzania involuta	Lethocolea pansa
Bryum ?chrysoneuron	Leucobryum candidum	Cephaloziella exiliflora	Lophocolea bispinosa
Bryum pachytheca	Macromitrium archeri	Cephaloziella hirta	Lophocolea cf. villosa
Calyptopogon mnioides	Macromitrium tenue	Chaetophyllopsis whiteleggei	Lophocolea muricata
Campylopus clavatus	Mittenia plumula	Chiloscyphus coalitus	Lophocolea semiteres
Campylopus introflexus	Orthodontium lineare	Chiloscyphus fissistipus	Metzgeria decipiens
Campylopus pyriformis	Orthotrichum tasmanicum	Fossombronia sp.	Metzgeria furcata
Cyathophorum bulbosum	Pohlia nutans	Frullania clavata	Metzgeria ?hispidissima
Dicranoloma billardierei	Polytrichum commune	Frullania falciloba	Plagiochila fasciculata
Dicranoloma dicarpum	Polytrichum juniperinum	Frullania prosciphora	Radula buccinifera
Dicranoloma platycaulon	Ptychomnion aciculare	Frullania rostrata	Radula compacta
Dicranella dietrichiae	Rhizogonium distichum	Goebelobryum unguiculatum	Riccardia aequicellularis
Ditrichum difficile	Rhynchostegium tenuifolium	Hyalolepidozia longiscypha	Riccardia cochleata
Entosthodon subnudus var. gracilis	Sematophyllum amoenum	Kurzia compacta	Riccardia crassa
Eriopus apiculatus	Sematophyllum homomallum	Kurzia ?uleana	Symphyogyna podophylla
Fissidens oblongifolius	Sphagnum australe	Lepidozia ulothrix sp. agg.	Telaranea centipes
Fissidens pallidus	Sphagnum cymbifolioides		Tylimanthus tenellus
			Zoopsis argentea
			Zoopsis leitgebiana

Brush-Tailed Phascogale *Phascogale tapoatafa* at Rushworth State Forest

Susan Myers[1] and Stuart Dashper[1]

The Fauna Survey Group (FSG) of the FNCV has been monitoring and collecting data on nestboxes erected in the Rushworth State Forest. This work was initiated originally by T. Soderquist and B.Traill in conjunction with the Australian Trust for Conservation Volunteers in 1992 and boxes were also erected by the FSG in January 1996. Currently 142 nestboxes are monitored by the group. They are checked every 4-6 months, the most recent check of the boxes was carried out in January 1997. The boxes were designed with small entrance holes of about 35 mm diam. in order to target small mammals, specifically Sugar Glider *Petaurus breviceps* and Brush-tailed Phascogale *Phascogale tapoatafa*. They were placed on rough-barked trees, mainly Greybox and Ironbark species with the aim of detecting the presence of Phascogales in Rushworth State Forest.

Two sites in particular have been fruitful with regard to the Brush-tailed Phascogale. In one specific nestbox which is situated in an area of fairly degraded Box-Ironbark woodland that has had trees removed for firewood etc. we have found heavy usage by Brush-tailed Phascogales. In December 1995 logging was taking place at the site, and the boxes were in a state of disrepair. The nestboxes were subsequently repaired by the FSG. In May 1996 two FSG members observed a pair of Phascogales mating in the totally undecorated box. The male was observed to have a tight grip on the back of the female's neck and there was a lot of saliva. This is thought to be an extremely rare sighting. In September 1996 a single adult Phascogale was found to be using the box in which an elaborate maternal nest had been constructed. In January 1997 three Phascogales were observed sleeping in the box. These animals were later observed leaving the box at dusk. One animal left the box at

approximately 20.55 hours. It initially stuck its head out of the box 2–3 times, then left and stood on the lid for 1–2 minutes sniffing the air and seemingly chewing on the metal catches of the box. It then climbed up the tree trunk for a short while before descending to the ground and moving away. The other two Phascogales left the box at approximately 21.08 and 21.10 hours. The second animal seemed very alert and wary and tapped vigorously on the nestbox lid, but both animals behaved much as the first animal. We were of the opinion that these were juveniles and that the first animal to exit was a young male as it appeared slightly larger and bolder. The two other animals appeared smaller and more timid, so were possibly young females. However, this is pure conjecture. These Phascogales may even have been reared in this very box.

Also of great interest, in another nestbox on the next tree (105 m distant) we found the mummified remains of two young Sugar Gliders whose skulls had clearly been crushed and the soft tissue eaten away. We are of the opinion that this was the work of a Phascogale as these are the only animals small enough to fit in the 35 mm diam. entrance and big enough to kill Sugar Gliders. Whether it was their neighbours, or Phascogales from another territory is obviously unknown. We can only imagine the scenario of a Phascogale dispatching two gliders almost simultaneously!

The apparently continuous occupation of a single nestbox by more than one generation of Phascogale, an animal that usually moves between nesting hollows, is possibly related to the lack of natural hollows in this overlogged forest. The animals that remain are dependent on artificial hollows and may be more vulnerable to predation.

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Notes on a New Survey Technique in Locating the Alpine She-oak Skink *Cyclodomorphus praealtus* in the Mount Hotham Area, Victoria.

Dean Heinze[1]

The She-oak Skinks *Cyclodomorphus* sp. are medium sized lizards (to 30 cm) which have slender bodies and short limbs. They are closely related to the Blue-tongue Skinks *Tiliqua* sp. (Cogger 1994) (Fig.1). The Alpine She-oak Skink *Cyclodomorphus praealtus* is a secretive, rarely encountered species that occurs in alpine areas (Green and Osborne 1994). It is currently listed as a threatened species under the Flora and Fauna Guarantee Act (Victoria).

In January 1995 participants and instructors from the Alpine Ecology Course (Conservation and Natural Resources, La Trobe University) observed six Alpine She-oak Skinks sheltering under small sheets of metal in the Mount Hotham area (Schulz *et al.* 1995). This finding led to Schulz *et al.* (1995) developing the idea of using metal sheets as shelter or 'trap' sites to survey the species. It was anticipated that the technique would act in a similar fashion as trapsites in transect and grid configurations used in small mammal trapping surveys to calculate population densities. The following account is of the initial field experimental stage of the technique.

Prior to Winter 1995 ten sites were selected in the Mount Hotham area, the sites included areas of Snow Gum woodland, open heathland and grasslands (I. Mansergh *pers. comm.*; McDougall 1981). Each site consisted of a 50 m transect with ten galvanised iron sheets 25x25 cm (Schulz Reptile Trap manufactured by Elliot Scientific Equipment) fixed to the substrate at five metre intervals. In Spring 1995 a 50 m 10x10 grid site was also set (Table 1).

Over Spring and Summer (November - March) 1995/96 the sites were visited on four occasions. Five reptile species were observed using the sheets, a further two reptiles were observed but not identified to species level. Alpine She-oak Skinks were observed on four occasions, one gravid individual was recorded twice using the same sheet over a two week period (Table 2).

All Alpine She-oak Skinks encountered

were from areas of open heathland/grassland with a soil substrate and a high *Poa* sp. tussock density - habitat preferences of the species as described by Green and Osborne (1994) and Shea (1995). Sites on exposed open heathland (north-west aspect) with a rocky substrate were unsuccessful. At some dry and exposed sites the sheets were used by nesting ants which appear to deter other species from sheltering under the sheets. Many invertebrate species were observed using the sheets.

These preliminary results confirm that the technique is successful for observing reptile species. However, its application appears to be more appropriate for long term studies rather than for immediate searches where rock rolling or litter searches may be more productive.

The 1995/1996 summer was unusually wet, and it is possible that the Schulz Reptile Trap will be more effective as a survey technique over a warmer summer. Given the success of the technique, the survey will continue in 1997, and it is anticipated that the method will be used to obtain more information about the distribution and ecology of the Alpine She-oak

Fig. 1. Juvenile Alpine She-oak Skink *Cyclodomorphus praealtus*. Mt.Higginbotham Site 7.

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Skink and other species which have been conventionally difficult to survey. This trap is also being trialed in non-alpine areas (I. Mansergh *pers. comm.*).

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Table 1. Reptile survey site details in the Mount Hotham area.
Key: *1-10 = each site is a transect line of 10 sheets spaced at 5 metre intervals; *11 = 100 sheets on a 50x50 m grid, sheets spaced at 5 m intervals.

Site	Location	Lat./Long.	Habitat
1	Mt Hotham Summit	36°58'27" 147°07'45"	Open heathland on a rocky substrate.
2	Mt Hotham Summit	36°58'33" 147°07'42"	*Poa hiemata* grassland - open heathland on a soil substrate.
3	Mt Loch Car Park	36°58'30" 147°08'08"	Open heathland on a soil substrate, some disturbance.
4	Mt Loch Track	36°58'20" 147°08'20"	Wet open heathland on a soil substrate, weeds present.
5	Mt Loch Track	35°58'16" 147°08'24"	Open heathland on a soil substrate & Snow Gum woodland on a rocky substrate, weeds present.
6	Mt Little Baldy	36°59'02" 147°06'10"	Highly exposed open heathland on a rocky substrate.
7	Mt Higginbotham	39°59'12" 147°08'30"	*Poa hiemata* grassland - open heathland on a soil substrate.
8	Mt Higginbotham	36°59'17" 147°08'24"	*Poa hiemata* grassland & Snow Gum woodland on a soil substrate.
9	Mt Lt Higginbotham	36°59'37" 147°09'15"	Snow gum woodland over open heathland on a soil substrate.
10	Mt Lt Higginbotham	39°59'40" 148°07'39"	Open heathland on a disturbed road cutting on an exposed soil substrate.
11	Mt Hotham Summit	36°58'30" 147°07'28"	Exposed open heathland on a rocky substrate.

Table 2. Reptiles observed on or under Schulz Reptile Traps at Mount Hotham.
Key: * Encounters - individuals identified using sheets; + Individuals identified basking on sheets. R marked animal recaptured; # Individuals not held to be identified.

Date	Site	Species observed	Common Name	No.*	Time observed-Conditions
13/11/95	6	*Drysdalia coronoides*	White-lipped Snake	1	4.00pm - sunny
	7	*Pseudemoia Sp.*	Skink	2#	3.30pm - sunny
26/1/96	2	*Pseudemoia entrecasteauxii*	Southern Grass Skink	1	4.00pm - sunny
27/1/96	7	*Cyclodomorphus praealtus*	Alpine She-oak Skink	1	10.30am - sunny
	6	*Nannoscincus maccoyi*	McCoy's Skink	1	11.00am - sunny
4/3/96	4	*Cyclodomorphus praealtus*	Alpine She-oak Skink	1	6.00pm - sunny
	2	*Pseudemoia entrecasteauxii*	Southern Grass Skink	1	6.45pm - cloudy
	2	*Cyclodomorphus praealtus*	Alpine She-oak Skink	1	6.45pm - cloudy
	11	*Pseudemoia entrecasteauxii*	Southern Grass Skink	1	7.00pm - cloudy
5/3/96	6	*Pseudemoia entrecasteauxii*	Southern Grass Skink	1	2.00pm - sunny
	2	*Pseudemoia entrecasteauxii*	Southern Grass Skink	1	2.15pm - sunny
	11	Unidentified Skink		1#	3.00pm - sunny
	11	*Pseudemoia pagenstecheri*	Southern Tussock Skink	1+	"
13/3/96	4	*Cyclodomorphus praealtus*	Alpine She-oak Skink	1 (R)	6.15pm - sunny

New Location for the Alpine She-oak Skink
Cyclodomorphus praealtus in Victoria

Martin Schulz[1] and Ian Mansergh[2]

The Alpine She-oak Skink *Cyclo-domorphus praealtus* has been recorded from alpine grasslands and low heathlands (after McDougall 1982) in the Mt. Hotham, Mt. Loch, Lankey Plains and Mt. Buffalo areas of Victoria (Schulz *et al.* 1995; Jenkins and Bartell 1980). At present species in the *Cyclodomorphus* complex are regarded as vulnerable in Victoria (CNR 1993) and *C. praealtus* is suggested to be very uncommon throughout its range in the Australian Alps above 1500 m (Green and Osborne 1994). This note presents details of the occurrence of *C. praealtus* on the Bogong High Plains, a new location for the species.

Cyclodomorphus praealtus was recorded at four locations on the Bogong High Plains during an intensive search for the species with participants in the Alpine Ecology Course (Flora and Fauna Branch, Department of Natural Resources and Environment) (Table 1). Schulz *et al.* (1995) recorded this species sheltering exclusively under small pieces of galvanised iron in the Mt. Hotham and Mt. Loch areas. In contrast, all individuals (n=17) located on the Bogong High Plains were found resting under, or seen on, rocks. The altitude of the locations ranged from 1630–1740 m and occurred in three plant communities: rocky grassland; closed heathland, and open heathland (after McDougall 1982). The highest number of individuals per search effort was located at Site Two (1.3 individuals per search hour) and Site Three (1.2 individuals per search hour). Five reptile species were found in sympatry, with two species, the Southern Tussock Skink *Pseudemoia pagenstecheri* and White-lipped Snake *Drysdalia coronoides* located in all four sites.

Cogger (1996) recorded a snout-vent length of 130 mm for *C. casuarinae* but provided no measurements for *C. praealtus*. Green and

Osborne (1994) noted a snout-vent length of 'about 10 cm' and a slightly shorter tail of 'about 8 cm'. In individuals captured and measured (n=14) on the Bogong High Plains the snout-vent length ranged from 85–116 mm, while the tail length ranged from 11–84 mm. The large range in measurements was due to the capture of immature, subadult and adult individuals; the range of measurements for tail length was further compounded by a number of individuals with regenerating tails. Similarly, the weight of individuals varied widely from 2.5–21.0 g.

The *C. praealtus* sites were under a variety of current land management regimes. The two individuals in Site One were located in open heathland 4–5 m from the edge of a ski-tow storage facility in the Falls Creek Ski Area. Individuals in Site Two were located under rocks that had been piled up on the side of a track into a disused quarry within the Falls Creek Ski Area. Sites Three and Four were in the Alpine National Park in areas that are currently grazed by cattle in the summer period.

Five additonal sites were searched for *C. praealtus* without locating any further individuals (Table 2). These areas were searched in a similar manner with all movable rocks being inspected for sheltering individuals.

The location of *C. praealtus* in four sites on the Bogong High Plains in January 1997 is somewhat puzzling. In previous years during early January, as part of the Alpine Ecology Course run by the Department of Natural Resources and Environment, a number of the same sites had been searched in a similar manner for the species (Schulz *et al.* 1995). In addition, previous fauna surveys on parts of the Bogong High Plains failed to locate the species (e.g. Pyrke *et al.* 1988; Norris and Mansergh 1981) and earlier unpublished searches by herpetologists also failed to locate the species (P. Robertson *pers. comm.*). The relative ease of locating the species using a standard reptile searching method (*viz.* rock-rolling) in January 1997 suggests that abundance of *C. praealtus* at

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known localities is highly variable between years. Such variability is possibly related to a certain as yet unrecognised suite of weather conditions. This aspect of the ecology of *C. praealtus* must be considered in any future work investigating aspects of the biology, habitat preferences and management of the species.

Acknowledgements

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Table 1. Details of *C. praealtus* sites on the Bogong High Plains, January 1997.
* after McDougall, 1982; Search effort in hours

Site	Location	Grid Ref.	Alt. (m)	Date	Veg Type*	Search Effort	No. Found	Other Reptile Species
1	North East of Ruined Castle	36°52' 147°16'	1660	9/1/97	Open heathland	9.0	2	*E. whitii,* *E. tympanum,* *P. entrecasteauxii* *P. pagenstecheri,* *D. coronoides*
2	Ruined Castle	36°52' 147°15'	1740	9/1/97	Rocky grassland & closed heathland	7.5	10	*E. tympanum,* *P. pagenstecheri,* *D. coronoides*
3	North side of Basalt Hill	36°53' 147°19'	1630	10/1/97	Open heathland	3.3	4	*P. pagenstecheri.* *D. coronoides*
4	Rocky Valley plots	36°53' 147°17'	1680	10/1/97	Open heathland	6.7	1	*E. whitii.* *P.entrecasteauxii,* *P. pagenstecheri.* *D. coronoides*

Table 2. Sites where no *C. praealtus* were recorded on the Bogong High Plains, January 1997.
*after McDougall, 1982; Search Effort in hours.

Site	Location	Grid Ref.	Alt. (m)	Date	Veg. Type*	Search Effort	Other Reptile Species
5	Timms Spur	36°48' 147°18'	1810	10/1/97	Rocky grassland and closed heathland	3.3	*P. pagenstecheri*
6	Spion Kopje Track	36°49' 147°19'	1880	10/1/97	Rocky grassland	4.0	*P. pagenstecheri,* *D. coronoides*
7	Mt. Nelse North	36°49' 147°19'	1870	10/1/97	Rocky grassland	3.0	*P. pagenstecheri,* *D. coronoides*
8	Cope Creek headwaters	36°54' 147°18'	1700	8/1/97	Poa tussock grassland and bog	4.0	*E. kosciuskoi,* *P. pagenstecheri,* *D. coronoides*
9	Mt. Nelse Road	36°52' 147°18'	1610	9/1/97	Open heathland	3.3	*P.entrecasteauxii* *P. pagenstecheri,* *D. coronoides*

Botany by Bicycle

R.J. Fletcher[1]

Among the indefatigable botanical amateurs and collectors of the late nineteenth and early twentieth centuries, Herbert Bennett Williamson must be placed in the higher ranks. Born at Beechworth in 1860, just eight years after Ferdinand Mueller had arrived in Victoria at the age of twenty-seven, he became personally acquainted with Mueller, for whom he was an important collector.

At about age forty, Williamson was elected a Fellow of the Linnean Society for his services to botany. He was a distinguished primary teacher, retiring from the Dandenong Primary School in 1925. Many of his extensive excursions were made during the school vacations. In the years immediately before and after his retirement, he made extended journeys to the high country of East Gippsland, especially the Bogong High Plains.

One of his more memorable trips was reported in *The Victorian Naturalist*, **28**, (1911). The article was titled 'A Cycle Trip Through East Gippsland', and was made during part of the summer vacation, 29 December 1910, to 10 January 1911. From Bairnsdale, he travelled 240 miles (386 km) by bicycle (Fig.1). The object of this paper is to report the retracing of his steps as far as is practicable.

He did the trip alone, and concluded his report by stating that his 'ideal for a trip to these parts can be summed up thus: a strong, staunch horse, a covered wagonette, food supplies and blankets, and a congenial mate or two'.

The author of this report left his bicycle at home, but did have a number of staunch horses under the bonnet of the car, a covered wagonette in the form of a camper-trailer, food supplies and blankets.

Williamson was known to several people in East Gippsland, including friends who had collected for him in the Orbost district, and the purposes of his trip were to renew their acquaintance, observe the living plants in their natural setting, and to gain some knowledge of the birds of Gippsland.

This author and friend set out on

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December 27, 1995, with similar objects in view, and arrived at Swan Reach that afternoon. Williamson had been singularly impressed by the beauty of the Tambo River and the hydraulically operated bridge, erected in 1905, which enabled steamers to go up the river as far as Mossiface. The Tambo is still a river of great beauty, and a mecca for tourists, especially boating people.

The lift bridge which had so impressed Williamson collapsed in 1925 from attacks by the Teredo Worm *Teredo avalis*, and a temporary replacement served until carried away by flood in 1930.A new permanent bridge was then constructed, but it was not a lift bridge, and that fact, together with the extension of the railway beyond Bairnsdale, spelled the end of the river trade. This bridge served until the present time, its replacement being officially opened on December 19, 1995. Our objective here was the start of the Old Orbost Road, to find which you go under the new bridge on the Tambo Upper Road and turn right.

In planning this trip, it was originally assumed that Williamson had travelled by way of Lakes Entrance, but the fact that it was not mentioned in his report at this stage raised a query. Then it was found that there is still a section of road between Swan Reach and the Colquhoun State Forest called the Old Orbost Road. Reference to earlier maps showed that there was a direct route, called the Old Nowa Nowa Road, from Swan Reach to Nowa Nowa as late as 1942. This same route now has various sections with different names. The first section is called Old Orbost Road, then Bruce Track, Ford Track and Old Colquhoun Road And this is the route we followed from Swan Reach to Nowa Nowa.

Another puzzle is where Williamson slept that night. He reported that he had arrived in Nowa Nowa in time for breakfast, having received a lift in a wagonette whose driver wanted company. The result was that no mention was made of the forest he was passing through, his aim being to get to Orbost, though not to the exclusion of all else. We selected a spot near the intersec-
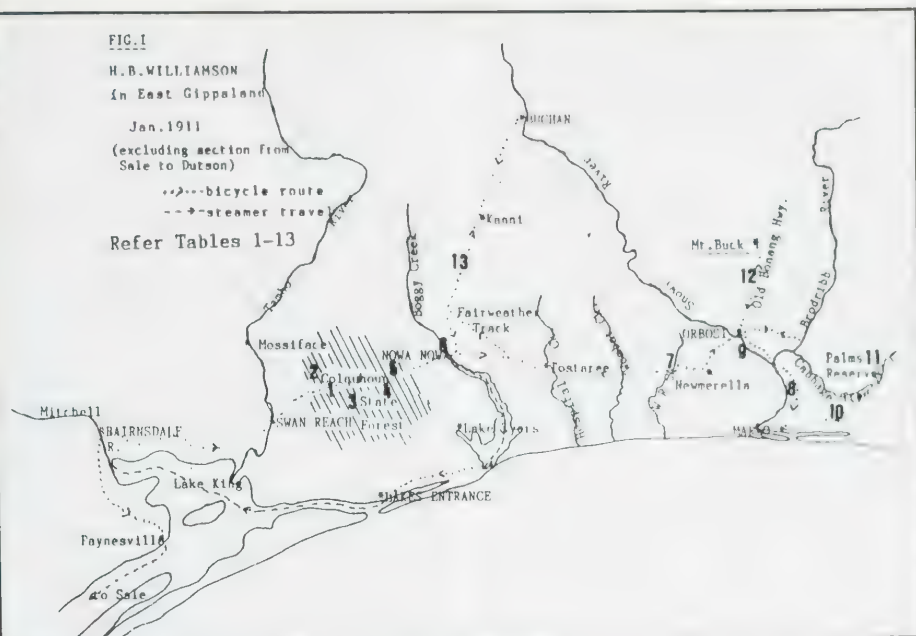
Fig. 1. Map of H.B. Williiamson route in East Gippsland.

tion of West Boundary Track and Bruce Track to spend the night, but had time to look around the immediate vicinity. Having done so, we decided that this was the place to begin our bird and plant lists, the emphasis being on the latter (Table 1). We felt that the trip had begun satisfactorily and called it a day, wondering if Williamson also had so many mosquitoes for company!

We decided not to press on to Nowa Nowa in time for breakfast, but to spend a day in the Colquhoun State Forest. We began by walking along the West Boundary Track and Bruce Track, and noted activities, both scratchings and faeces, of Echidna *Tachyglossus aculeatus* and Red-necked Wallaby *Macropus rufogriseus*. Additions were made to the plant list for this area to include those in Table 2. Amongst these were Rufous Greenhood (Fig.2) and Rosy Hyacinth Orchid (Fig. 3). Also in this area were excellent specimens of the fungi *Amanita ananaceps* and *A. ocrophylla*.

The remainder of the morning and all of the afternoon was spent making a circuit of some of the tracks such as Bruce Track, Oil Bore Road, part of Colquhoun Road, Box Spur Track, Uncles Road, Quarry Road and sundry unnamed tracks. The quarry referred to in Quarry Road was the

source of much of the granite used in building the port at Lakes Entrance, and there is now a walking track, the Mississippi Track, which in part follows the old tramway over which the granite was transported. We also added to the bird list along these tracks and these are recorded in Table 3. Not far from the quarry we also noted the arch enemy of the birds, a well-grown specimen of Feral Cat *Felis catus*.

During the tour of this forest most of the plants noted in Tables 1 and 2 were seen again and several more were added. (Table 4.)

The next morning we resumed retracing Williamson's tracks to Nowa Nowa along the Old Colquhoun Road. There is a definite change in habitat as the road partly follows Mundic Creek and some plants not noted by us previously are listed in Table 5.

Some items worth noting along this section would not have been there in Williamson's time. The railway to Orbost was not opened until 1916, at which time the amazing trestle bridge (Fig. 4), one of a standard type of construction at the time, was built. This bridge is now maintained as a tourist attraction, the railway having closed in 1987 (Fig. 5). Just before the bridge, on Mundic Creek, is Costick's

Fig. 2. Rufous Greenhood *Pterostylis* ap. aff *rufa* near the West Boundary Track, Colquhoun State Forest.

Weir, a delightful spot deserving of more time than we gave it. This weir was one of a number built in the area during the late 1930's and early 1940's under the supervision of John Costick, a senior Forestry Officer. Their purpose was to provide water for fire-fighting.

We arrived in Nowa Nowa in time for lunch, which was taken in the shade just above the Gorge on Boggy Creek. Like Williamson, we wondered why it was called Boggy Creek.

Basking on a rock near the water's edge, just upstream from the bridge, was an Eastern Water-dragon *Physignathus lesuerii*, but as is the habit of its kind it slid off into the water. Two more birds were added to our list here, Brush Bronzewing *Phaps elegans* and Peaceful Dove *Geopelia striata*.

Williamson had remarked that the month of November would probably be the peak time for observing plants in flower here, and he was probably correct. He saw Hairy

Fig. 3. Rosy Hyacinth Orchid *Dipodium roseum*, commonly seen in many parts of East Gippsland during the summer months.

Mint-bush *Prostanthera hirtula* in bloom, and Kanooka. We saw the latter in flower but not the former.

However, a walk along the creek bank, from the recreation area south of the highway to the Gorge yielded a good list of plants, though not all were in flower, (Table 6). Many of these were competing with numerous grasses, mostly introduced species, and the ubiquitous Blackberry *Rubus polyanthemus*.

Local information from Mr and Mrs Kingston indicated that the hotel where Williamson had dined was on the high ground near the bridge across Boggy Creek. They also informed us that the steamers on Lake Tyers used to tie up close to where the boat ramp is now situated. They were also the source of the information concerning John Costick and Costick's Weir.

During the afternoon we continued towards Orbost, as had Williamson, except that it was our intention to camp along the way somewhere near Hospital Creek, which was one of the spots he mentioned. However we found no suitable site, and after observing that in or near the creek were Maiden Hair-fern, Soft Water-fern

Fig. 4. The fascinating structure of the Stoney Creek Railway Bridge. No longer functional, but kept as a tourist attraction.

Fig. 5. Remains of the Bairnsdale/Orbost railway at 'Colquhoun' in the Colquhoun State Forest. Likely to become the route of a section of the Sale-Sydney natural gas line.

Blechnum minus and #Water Ribbons *Triglochin procera*, we spent some time wandering around the tracks in this vicinity, finally setting up camp at W R Creek. A pair of Whipbirds *Psophodes olivaceus* (# as *P. crepitans*) entertained us while camp was established and from time to time were joined by Horsefield's Bronze Cuckoo, #Bellbird *Manorina melanophrys*, Flame Robin *Petroica phoenecia*, Eastern Spinebill and, later in the evening, by the Boobook Owl *Ninox novaeseelandia*

Next morning, the beginning of our fourth day out, there was light rain, adding to the already very warm and humid conditions. However, the rain soon cleared and we walked a circuit through the bush, along the old railway line, and back along the partly overgrown remains of the former highway. What had, at first, appeared a rather unpromising site, carried quite a wide range of plants, including those listed in Table 7. Mosquitoes were particularly active in the area as were several Echidna *Tachyglossus aculeatus*.

We finally moved on to Orbost, stopping at Newmerella to take in the view of the Snowy River flats. The highway route has changed since 1911, in fact after the 1970

floods, but it is still possible to go the old way down a steep road cut around a limestone bluff. And that is the way we went. Without delay we started on the road to Marlo.

When Williamson came this way on the last day of 1910 he reported vast acreages of corn and beans, with a corn crib on practically every property. The largest of these was 450 feet (137 m) long , 7 feet (2.1 m) wide, and filled to 10 feet (3 m) with corncobs. In 1995 there were three cribs remaining, one in a reasonable condition on the Marlo Road, and two dilapidated ones on the Lochend Road (Fig. 6). None are used for the original purpose. In 1910, 7000 acres (2830 ha) were under corn or maize, and 300 acres (120 ha) under beans. At the time of our visit there were 300 acres (120 ha) under corn and 250 acres (100 ha) under beans. These crops are controlled by the Snowy River Seeds Co-operative and are processed for seed to be grown in other areas. About 75 acres (30 ha) are sown to capsicums by a private grower. The rest of the Snowy River flats are used for raising beef and dairy cattle, these being more economically viable than the seed crops.

The first part of the road to Marlo is the same route that Williamson took and follows

Fig. 6. Remains of a corn-crib on the Lochend Road, Orbost. Once a proud structure on most properties on the Snowy River flats.

the Snowy River. The vegetation along the roadside and river bank (Table 8), then, as now, included many exotic weed plants. Among them are occasional specimens of Chicory*, and one wonders if these are garden escapes of more recent times or descendants of experimental crops grown early in the century.

Williamson remarked in his diary that on the other side of the river from the Marlo Road there was a tangle of various trees and their attendant parasites and climbers. He must have had excellent eyesight to distinguish some of the plants he listed, or he may have relied on the list published by his friend, Dr C.S. Sutton two years earlier, which he later acknowledged. We visited the other side of the river a few days later to explore this remnant jungle on the Lochend Road and recorded the plants listed in Table 9. At least one of the plants in this list is on the rare or threatened Australian plant register. Unfortunately this remnant has for many years been separated by the road from the protecting cliff of the Devil's Backbone, and this has allowed the access of many weed plants other than those listed. Here we also spotted a Sacred Kingfisher *Halcyon sancta*.

A little over a kilometre before you reach the Brodribb River on the Marlo Road, the Snowy River takes a sweeping turn to the west, and originally the road followed this to a bridge about 600 m downstream from the present one. There are remnants of the piles of the original bridge on the southern bank of the river where the boat ramp is now situated.

Williamson had stopped overnight in Marlo, but it was our intention to go on and camp somewhere near the Palms Reserve, which was one of the major attractions for him.The present road out of Marlo is not the original, which, locals say, was probably where Jorgensen Street is now. Williamson had ridden along this road but missed the turn-off to Cabbage Tree Creek, and by the time he realised his error it was too late to go on. However, he set off again next morning, New Year's Day 1911, with fresh directions and had no problem finding the spot. The indigenous vegetation along Cape Conran Road is very likely much the same as it was eighty-five years ago, predominately Messmate, Mahogany Gum, Saw Banksia, and Burgan.

Much of the land that Williamson would have cycled through from Marlo to Cabbage Tree Creek has been, and is still being, cleared, but is still home for many birds and plants. Among the birds seen were: Bellbird *Manorina melanophrys*, Little Raven *Corvus mellori*. Brush Bronzewing *Phaps elegans*, Pied Currawong *Strepera graculina*, Crimson Rosella and Wedgetailed Eagle *Aquila audax*. Plants noted along the Cabbage Tree/Marlo Road are listed in Table 10.

Where Williamson saw an unobtrusive notice 'To The Palms' the track is now wide and clearly signposted. He had been able to spend only a brief time here before being driven off by hordes of mosquitoes. There are still hordes of mosquitoes as well as ticks and leeches in the Reserve area. However, we had planned to spend a little time here and set up camp further along Palms Track well away from the Reserve. Williamson had felt a sense of history, standing where Mueller had stood fifty years previously. He felt that a fitting gesture would be to call the area *Mueller's Park* and the principal feature *Mueller's Palms*. We stood on the same spot one hundred and forty years after Mueller and wondered what the track in had been like then.

Early on New Year's Eve 1995, with misty rain and very humid conditions, we rejoined the mosquitoes at the Reserve to examine this isolated remnant of Cabbage Fan-palm (Fig. 7). There had recently been heavy rain in Gippsland and it was obvious that the Cabbage Tree Creek had been in flood. Williamson had remarked that although there were palms of various ages

Fig. 7. Cabbage Fan-palm *Livistona australis* at the Cabbage Tree Creek Reserve between Marlo and Cabbage Tree.

in the area, he had found no seedlings. Whether or not it was the result of the recent inundation we don't know, but there were scores of young seedlings.

Besides the ubiquitous Bellbirds *Manorina melanophrys* and, no doubt attracted by the copious amount of seeds on the palms, we noted the Sulphur-crested Cockatoo *Cacatua galerita* and the Gang-Gang Cockatoo *Callocephalon fimbriatum*. The particular conditions which allow the palms to grow here are no doubt responsible for an astonishing variety of other rainforest plants to flourish. Our observations are listed in Table 11. Compiling this list occupied the whole of the morning.

Because of the weather conditions and the fact that we did not, like Williamson, have to cycle all the way, we took the afternoon off, this being New Year's Eve, and went for a swim at Cape Conran.

On the morning of New Year's Day, having the survived the storms that swept the State during the night, we figuratively cycled to the place where the Princes Highway crosses the Brodribb River. Williamson had found a patch of native vegetation left in the corner of a cultivation paddock, including in his list Gippsland Orange or Yellow Wood *Acronychia laevis* now *A. oblongifolia*. This is no longer to be found just here, a casualty of clearing, quarrying and road building. There are some hardy remnants: Mahogany Gum, Burgan+, Coral Pea, Silver Wattle, Blackwood and Shiny Cassinia+. At Youngs Creek, a little to the west, Williamson had seen the Butterfly Orchid *Sarchochilus parviflorus* now *S. australis*. This is still to be found in the area, but certainly not near the highway.

On the following morning he rode, or at least walked and rode, up to Mt. Buck. We suspect that most of this leg of the trip would have been walked, as the gradient of the Old Bonang Highway, still quite trafficable, would not allow much time in the saddle. He would have enjoyed the trip back down much more. Williamson was particularly struck with the apparent resemblance of the higher gullies to some in the Otway Range. He clambered down one which seemed from the road to be a typical Otway Forest musk gully, but soon noted that the climbing plants were in greater number and variety. He found a

specimen of Red Passion-flower *Passiflora cinnabarina* but not in flower or fruit. We did not find this particular species, perhaps not going far enough into the gully, but were rewarded with seeing the plants listed in Table 12.

A feature of the bush between the Old Bonang Highway and Mt. Buck along Cooney Ridge Road is the number of variations in the foliage of the Elderberry Panax. This variable shrub exhibits, in this area, most of the leaflet shapes associated with it, from entire to pinnate with toothed margins, and those with the ferny appearance, having very narrow pinnules. This would be an interesting place to spend more time but inclement weather and the attentions of the mosquitoes forced us to retreat.

Williamson's next move was to Buchan by way of a newly opened track, now called Fairweather Track, thus by-passing Nowa Nowa. This was also our route, but in contrast with the dusty coach-road he found, the conditions at this time were quite wet. He was unimpressed with the forest of tall eucalypts with no scrub. Perhaps some clearing and logging over the years has opened up the forest and encouraged undergrowth. Table 13 includes many of the plants to be seen along this track.

At the time Williamson travelled this road there was a Half-way House in the area of Kanni Creek where tea and soft drinks were dispensed. There being no such facility now, our camp was set up in this area where Williamson had recorded *Eucalyptus pulverulenta*. Not being up with the latest nomenclature, this was something of a puzzle, as this species grows only in New South Wales. Other eucalypts with the epithet Mealy Stringybark were not listed as growing here. A specimen was later taken to the C. N.R. Office at Nowa Nowa where the staff provided a photocopy of the relevant extract from Telopea which identified the tree as Silver-leafed Stringybark *Eucalyptus conspicua* (Fig. 8).

After yet another wet night, the weather cleared enough to allow a walk to be taken in the general area. On the higher ground, under the canopy of the *Eucalyptus conspicua*, there is quite a heathy undergrowth which includes those plants listed in **Table 13.** Further down the hill towards Kanni Creek

was the scene recorded by Williamson as a patch of Red Bottlebrush and a forest of Mealy Stringybark trees *Eucalyptus pulverulenta* (sic). The *Callistemon citrinus*, Williamson's *C. lanceolatus*, was in flower making a splendid show against the silver *E. conspicua*, his *E. pulverulenta*. Williamson had continued on into Buchan, enjoying the long downhill entry and his visit to the Fairy Cave, but not, one imagines, the long uphill trudge towards Nowa Nowa. He took the steamer from Nowa Nowa to Lakes Entrance. There are still remains of the old jetties at the southern end of Lake Tyers and a new one for a pleasure launch, but, of course, there is no longer a steamer. He then travelled to Bairnsdale by the steamer across Lake King. From Bairnsdale he cycled to Paynesville and took the steamer to Sale.

His objective at Sale was to visit an old friend, T.A. Robinson, at Dutson, an area he described as a splendid field for the botanist. The property he visited, which was at the time an extensive experimental

Fig. 8. Juvenile foliage of Silver-leaved Mountain Gum *Eucalyptus conspicua*, L. Johnson & K. Hill, listed by Williamson as *E. pulverulenta*.

garden, is now pasture only. A *Pinus* windbreak and a large Bay Laurel *Lauris nobilis* are probably the only reminders of earlier times.

There is a remnant of rather degraded bush nearby, but the continuing inclement weather discouraged any activity there. The roadside remnants include Lightwood, Black Wattle, Stringybarks *Eucalyptus* spp. and Prickly Tea-tree. However, the area may well be worth a visit in the springtime. Dutson concluded Williamson's journey which included over 380 km (240 miles) by bicycle. One's admiration for our predecessors, who did it the hard way, cannot help but be increased when the way we travel is so easy by comparison.

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Plants marked: + are those seen in flower; # are those appearing in Williamson's paper; are exotics.*

Table 1. Plant species list for the West Boundary Track.

Orchid, Onion *Microtis parviflora*+
Rush-lily, Yellow *Tricoryne elatior* +
Banksia, Saw *Banksia serrata*+
Burgan *Kunzea ericoides*+
Bursaria, Sweet *Bursaria spinosa*+
Guinea-flower, Rock *Hibbertia spathulata*+
Gum, Manna *Eucalyptus viminalis*
Hopbush, Giant *Dodonea viscosa*
Lightwood *Acacia implexa*
Pomaderris, Hazel *Pomaderris aspera*
Stringybark, Yellow *Eucalyptus muelleiana*
Violet , Showy *Viola betonicifolia*+
Violet, Ivy-leafed *V. hederacea*+
Wattle, Black *Acacia mearnsii*

Table 2 Additional plant species in West Boundary Track/Bruce Track Area.

Rock-fern, Narrow *Cheilanthes sieberi*
Flax-lily *Dianella revoluta*
Greenhood, Rufous *Pterostylis aff. rufa*+
Orchid, Rosy Hyacinth *Dipodium roseum* +
*Centaury, Common *Centaureum minus* +
Coral-pea, Dusky *Kennedia rubicunda*
Coral-pea, Purple *Hardenbergia violacea*
Glycine, Variable *Glycine tabacina*
Hound's -tongue, Sweet *Cynoglossum suaveolens*+
Marianth, White *Rhytidospermum procumbens*+
Rice-flower, Common *Pimelea humilis* +
*Speedwell, Persian *Veronica persica*+
Star, Yellow *Hypoxis vaginata*+

Table 3 A brief bird list for the Colquhoun State Forest.

Bronze Cuckoo, Horsefield's *Chrysococcyx basalis*
Chough, White-winged *Corcorax melanorhamphos*
Currawong, Pied *Strepera graculina*
Fantail, Grey *Rhipidura fuliginosa*
Magpie, Australian *Gymnorhyna tibicen*
Owl, Powerful *Ninox strenua* (heard, not seen)
Rosella, Eastern *Platycercus eximius*
Rosella, Crimson *P. elegans*
Spinebill, Eastern *Acanthorhynchus tenuirostris*
Tree Creeper, White-throated *Climacteris leucophoea*
Whistler, Golden, *Pachycephala pectoralis*

Table 4. Plant species in the Colquhoun State Forest in addition to those in Tables 1 and 2.

Ash, Silvertop *Eucalyptus sieberi*
Box, Red *E. polyanthemos*
Candles, Creamy *Stackhousia monogyna*+
Daisy-bush, Snowy *Olearia lirata*+
Fan-flower, Purple *Scaevola ramosissima*+
Geebung, Cluster-flowered *Persoonia confertifolia*+
Geebung, Narrow-leafed *P. linearis*+
Geebung, Prickly *P. juniperina*+
Ironbark, Red *Eucalyptus tricarpa*
Lobelia, Tall *Lobelia gibbosa*+
Lomatia, Holly-leafed *Lomatia ilicifolia*+
*Mullein, Twiggy *Verbascum virgatum*+
She-oak, Black *Allocasuarina littoralis*
Wattle, Sunshine *Acacia terminalis*

Table 5. Plant species along the Old Colqhoun Road and near Mundic Creek.

Grass-tree, Small *Xanthorrhoea minor*+

Banksia, Silver *Banksia marginata*+
Bitter-pea, Hop *Daviesia latifolia*
Christmas Bush *Prostanthera lasianthos*+
Correa, Common *Correa reflexa*
Kanooka *Tristaniopsis laurina* +
Lomatia, Long-leafed *Lomatia myricoides*+
Olive-berry, Blue *Elaeocarpus reticulatis*+

Table 6. Plant species list along Boggy Creek at Nowa Nowa below the Gorge included.

Blue-lily, Nodding *Stypandra glauca*
Wombat Berry *Eustrephus latifolius*

Box, Red *Eucalyptus polyanthemos*
Bramble, Queensland *Rubus hillii*
Burgan, *Kunzea ericoides*+
Buttons, Water, *Cotula coronopifoia*+
Correa, Common *Correa reflexa*
Daisy-Bush, Dusty *Olearia phlogopappa*
Daisy, Everlasting *Bracteantha bracteata*+
Gum, Manna *Eucalyptus viminalis*
Hopbush, Giant *Dodonea viscosa*
Howittia, Blue *Howittia trilocularis*+
Mock-Olive, Large *Notelaea longifloia*+
Monkey-flower, Creeping *Mimulus repens*+

Table 6 continued

*Mullein, Great *Verbascum thapsis*+
Paperbark, Swamp *Melaleuca ericifolia*
Tea-tree, Paperbark *Leptospermum trinervium*# (as *L. attenuatum*)
Tea-tree, Silky *L. myrsinoides*
Tea-tree, Woolly *L.lanigerum*+
Velvet-bush, Shrubby *Lasiopetalum macrophyllum*
Wattle, Silver *Acacia dealbata*
Wattle, Black *A. mearnsii*

Table 7. Plant species list near W R Creek.

Tree-fern, Rough *Cyathea australis*
Maidenhair-fern, Common *Adiantum aethiopicum*
Water-fern, Fishbone *Blechnum nudum*

Orchid, Onion *Microtis* sp.+
Orchid, Rosy Hyacinth *Dipodium roseum*+

Apple-berry, Common *Billardiera scandens*
Flat-pea, Handsome *Platylobium formosum*
Geebung, Narrow-leafed *Persoonia linearis*+
Guinea-flower, Bundled *Hibbertia fasciculata*+
Guinea Flower, Trailing *H. empetrifolia*+
Mistletoe, Creeping *Muellerina eucalyptoides*+
Milkwort, Heath *Comesperma ericinum*+
Paper-bark, Swamp *Melaleuca ericifolia*
Self-heal *Prunella vulgaris*+
Tea-tree, Prickly *Leptospermum continentale*
Tylophera, Bearded *Tylophera barbata*+

Table 8. Plants, mainly exotic, along the Marlo Road and Snowy River.

*Grass, Buffalo *Stenopetalum secundatum*

*Cherry, Madiera *Solanum pseudocapsicum*
*Chicory *Cichorium intybus*
*Dock *Rumex* spp.
Gum, Mahogany *Eucalyptus botryoides*#
Kangaroo Apple *Solanum aviculare*+
*Mullein, Great *Verbascum thapsis*+#
Tree Violet *Hymenanthera dentata*
*Verbena, Purple *Verbena bonariensis*+
*Willow *Salix* sp#

Table 9. Plant species in the remnant jungle on Lochend Road.

Felt-fern, Rock *Pyrossia ruprestris*

Sarsaparilla, Austral *Smilax australis*#
Wombat Berry *Eustrephius latifolius*

Blackwood *Acacia melanoxylon*#
Bolwarra *Eupomatia laurina*+
*Cherry, Madiera *Solanum pseudocapsicum*
Clematis, Forest *Clematis glycinoides*#
Elderberry, Yellow *Sambucus australasica*# (as *S. xanthocarpa*)
Gum, Mahogany *Eucalyptus botryoides*#
Kangaroo Apple *Solanum aviculare*+
Lightwood *Acacia implexa*

Table 9 continued.

Lilly Pilly *Acmena smithii#* (as *Eugenia smithii*)
Milk-vine, Yellow *Marsdenia flavescens*
*Passionfruit, Banana *Passiflora* sp
Tree Violet *Hymenanthera dentata*
*Verbena, Purple *Verbena bonariensis+*

Table 10. Species list of plants along the Cabbage Tree Creek Road.

Sedge, Saw *Gahnia* sp.

Banksia, Saw *Banksia serrata+#*
Bush-pea, Rough *Pultenaea scabra*
Dampiera, Blue *Dampiera stricta*
Fan-flower, Purple *Scaevola ramosissima+#*
Gum, Mahogany *Eucalyptus botryoides#*
Messmate *E. obliqua#*
Stringybark, Prickly *E. consideniana*
Stringybark, Yellow *E. muelleriana*
Wattle, Bower *Acacia cognata*
Wattle, Sunshine *A. terminalis*
Xanthosia, Woolly *Xanthosia pilosa*

Table 11. A species list of plants at the Palms Reserve.

Fan-palm, Cabbage *Livistona australis#*

Ground-fern, Austral *Hypolepis amaurorachis*
Maidenhair-fern *Adiantum aethiopicum*
Tree-fern, Rough *Cyathea australis*
Tree-fern, Smooth *Dicksonia antarctica*

Mat-rush, Spiny *Lomandra longifolia*
Sarsaparilla, Austral *Smilax australis#*
Saw-sedge *Gahnia* sp.
Wombat Berry *Eustrephus latifolius*

Blackwood *Acacia melanoxylon#*
Bramble, Queensland *Rubus hillii*
Bursaria, Sweet *Bursaria spinosa+*
Cassinia, Shiny *Cassinia longifolia+*
Christmas Bush *Prostanthera lasianthos+*
Clematis, Forest *Clematis glycinoides*
Coral-pea, Dusky *Kennedia rubicunda*
Currant -bush, Prickly *Coprosma quadrifida*
Glycine, Twining *Glycine clandestina*
Golden Tip *Goodia lotifolia*
Gum, Mountain Grey *Eucalyptus cypellocarpa*
Howittia, Blue *Howittia trilocularis*
Jungle Grape *Cissus hypoglauca#* (as *Vitis hypoglauca*)
Lilly Pilly *Acmena smithii#* (as *Eugenia smithii*)
Morinda, Jasmine *Morinda jasminoides*
Mulberry, Austral *Hedycaria angustifolia*
Panax, Elderberry *Sambucus gaudichaudiana+*
Pomaderris, Hazel *Pomaderris aspera*
Stringybark, Yellow *Eucalyptus muelleriana*
Swamp-mat, Shiny *Selliera radicans+*
Tylophera, Bearded *Tylophora barbata+*
Vine, Pearl *Sarcopetalum harveyanum*

Table 12. Species list along the Old Bonang Highway to Mt. Buck.

Tree-fern, Rough *Cyathea australis*

Fringe-lily, Common *Thysanotus tuberosus+*
Purple-flag, Leafy *Patersonia glabrata+*

Beard-heath, Lance *Leucopogon lanceolatus*
Blanket Leaf *Bedfordia arborescens+*
Dampiera, Blue *Dampiera stricta+*
Gum, Manna *Eucalyptus viminalis*
Gum, Mountain Grey *E. cypellocarpa*
Hopbush, Long-leaved *Dodonea triquetra*
Incense Plant *Calomeria amaranthoides*
Jungle Grape *Cyssus hypoglauca*
Loose-strife, Purple *Lythrum salicaria+*
Messmate *Eucalyptus obliqua*
Milkwort, Heath *Comesperma ericinum+*
Mock-olive, Large *Notelaea venosa+*
Mulberry, Austral *Hedycaria angustifolia*
Olive-berry, Blue *Elaeocarpus reticulatus+*
Panax, Elderberry *Polyscias sambucifolia*
Pultenaea, Soft *Pultenaea mollis*
Sheoak, Scrub *Allocasuarina paludosa*
Speedwell, Forest *Derwentia notabilis+*
Wattle, Cinnamon *Acacia leprosa*
Wattle, Myrtle *A. myrtifolia*
Wattle, Spreading *A. genistifolia*
Wattle, Sunshine *A. terminalis*
Wattle, Sweet *A. suaveolens*
Wattle, Varnish *A. verniciflua*

Table 13. Species of plants along Fairweather Track and the Kanni Creek area.

Fairweather Track.
Tree-fern, Rough *Cyathea australis*

Blue-lily, Nodding *Stypandra glauca*
Orchid, Onion *Microtis parviflora+*
Saw Sedge *Gahnia radula*

Ash, Silvertop *Eucalyptus sieberi*
Banksia, Saw *Banksia serrata+*
Banksia, Silver *B. marginata+*
Bottlebrush, Crimson *Callistemon citrinus+* (as *C. lanceolatus*)
Cherry Ballart *Exocarpus cupressiformis*
Flat-pea, Handsome *Platylobium formosum*
Messmate *Eucalyptus obliqua*
Paperbark, Scented *Melaleuca squarrosa*
Paperbark, Swamp *M. ericifolia*
Platysace, Shrubby *Platysace lanceolata+*
Rice-flower *Pimelea humilis+*
Sheoak, Black *Allocasuarina littoralis*

Kanni Creek area (in addition to those above) beneath the canopy of *Eucalyptus conspicua*.

Grass-tree, Small *Xanthorrhoea minor+*

Bitter-pea, Slender *Daviesia leptophylla*
Bush-pea, Rusty *Pultenaea hispidula*
Candles, Creamy *Stackhousia monogyna+*
Dampiera, Blue *Dampiera stricta*
Fan-flower, Purple *Scaevola ramosisima+*
Hakea, Bushy *Hakea sericea*
Platysace, Shrubby *Platysace lanceolata+*

Survival of Desert Banksia *Banksia ornata* Seed in Detached Cones

David Cheal[1]

Introduction

Most of the Desert Banksia *Banksia ornata* plants that were formerly so conspicuous in sandplain heathland in Wyperfeld National Park were killed by the severe frosts of 1981 (O'Brien 1989). As a result, *B. ornata* is now restricted to the tops of the low dunes, where the frosts were less severe and some *Banksia* survived. Nevertheless, over 90% of the *Banksia* died as a result of those frosts and much of the heathland now lacks this formerly dominant shrub (Fig. 1).

Following the death of the mature plants (which had been seedling regeneration from the 1959 wildfires) many of the follicles on the cones they carried gradually opened over the next few years and released their seed (Fig. 2). A very small proportion of these seeds germinated and grew, but not in sufficient numbers to reinstate the original density and dominance of *B. ornata*. However, it was noticed that a few cones, left scattered amongst the dead foliage and branches on the ground, had closed follicles and thus may have retained viable seeds.

Methods and Results

Banksia cones were collected in the 1959 regrowth that supported very few mature *Banksia*, but had a high density of dead shrubs. There were no standing dead *B. ornata* and most of the cones lying on the ground had open follicles, and no longer retained viable seed. Eight out of 47 cones present in a small, representative patch of heathland, retained some closed follicles. These cones were collected in 1994, 13 years after death of the plants.

After storage for a year, none of the closed follicles had opened. They were then placed in a drying oven at 40° C for six hours, but no further follicles opened. After eight hours at 60° C and a further eight hours at 80° C no further follicles opened. However, after six hours at 100° C all formerly closed follicles had begun to open. The cones were then taken out of the oven and the opening follicles forced further open and any seed extracted.

Discussion

In spite of lying on the ground, detached from the parent plants for 12 years, some cones of *B. ornata* retained viable seed. Many of the closed follicles showed evidence of insect attack and revealed only powder (frass) on opening. Only 17% of the cones lying on the ground retained closed follicles and these held only 5.7% of their formerly viable seeds. The current bank of viable seed is thus only 0.01% of the seed bank present when the 1981 frost killed the mature *Banksia*. Nevertheless, there is a remnant bank of viable seeds for *B. ornata* although there is no store of viable *Banksia* seed in the soil (Gill and McMahon 1986).

Owing to its large size and lack of features to assist long distance dispersal, seed

Fig. 1 Death of *Banskia ornata* in Wyperfeld National Park after frost in 1981.

Fig. 2 *Banskia ornata* in Wyperfeld, 12 years after death from frost (note the woody fruit retaining a few viable seeds).

[1] Parks and Wildlife Commission of the Northern Territory, P.O. Box 496, Palmerston, N.T. 0831.

Table 1. Seed bank of *Banksia ornata* in detached cones - Wyperfeld National Park

Cone number	1	2	3	4	5	6	7	8
No. closed follicles	5	13	4	11	1	21	14	6
No. of open follicles	4	1	11	3	8	1	1	9
Open follicles with seeds	0	1	0	0	0	0	0	0
No. of viable seeds	0	8	0	3	0	2	0	0
No. of seeds formed per cone	18	28	30	28	18	44	30	30

of *B. ornata* is expected to germinate close to the parent plants - so reinvasion from the few plants left alive on the low sandy rises will only occur after hundreds of years with fires at just the right frequency and season.

For most of Wyperfeld's older heaths (not burnt since 1959), the only hope for a return to widespread dominance by *B. ornata* is to encourage the release of the viable seed retained in the ageing cones lying scattered on the ground. Fire co-ordinates seed release and provides the best conditions for subsequent regeneration (Gill and McMahon 1986). Without fire, the follicles will *gradually* open and the seed will be lost to insect predation. With fire, the remaining seed will be released at once and some seed will escape insects, to germinate and grow.

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A Variation on the View Expressed in a Manuscript
Published in *The Victorian Naturalist*
Relating to Fire and Indigenous Land Management

William R. Archer[1]

Abstract
This paper seeks, with the assistance of a published opinion, to point out the disparity between traditional and European methods of fire management, thereby drawing attention to subtle differences of operation that can lead to major variances of performance. Factors are discussed that should be taken into account when considering indigenous environments requiring fire management. (*The Victorian Naturalist*, **114**, 1997, 192-195.)

Introduction

In the December 1995 issue, vol 112 (6) of *The Victorian Naturalist*, a paper by I.D. Lunt was published, titled 'European Management of Remnant Grassy Forests and Woodlands in Southeast Australia - Past, Present and Future'. It contained certain conclusions and recommendations that I suggest do not adequately take into account various natural and historical events relating to traditional aboriginal fire management and, if the published information were viewed from that perspective, very different solutions would eventuate from the facts presented.

I take this opportunity to state, that I sympathise with, and share, the general thrust of Ian Lunt's manuscript, plus acknowledge and respect the sincerity and quality of his research. Any differences of opinion relate purely to factual interpretation.

Seed distribution

In the above manuscript, it was concluded that the migration of *Caesia* seed would probably be extremely slow, as the seed was small with no adaptation for wind dispersal. It was assumed that if each succeeding generation of plants spread 2 m by seed drop and surface water dispersal, 1,000 years would be required for migration of only 1 km.

In the instance stated, I believe the power of the wind has been underestimated, it will move seed of *Caesia* size very easily, particularly in dry conditions following fire, when entire landscapes can be altered by the wind movement of sand, clay and ash. Any object lighter than the sand grains will also be transported during this process, wing appendages or seed shape are not essential

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for movement in these circumstances. The mallee in Western Australia is a particularly good example of this force in action. Here strong winds shift huge quantities of material, whereby seed from previous generations are exposed and redistributed, some in positions favourable for germination, others to be reburied and mixed in restructured soils now enriched with ash and clay particles (*pers. obs.*). This process is an important part of mallee ecology, resulting in a widespread pot pourri of plant species not unlike the original grass communities alluded to by Ian Lunt; I strongly suspect strong winds (from which Victoria is not immune) play an important part in the affairs of most relatively open, fire-prone environments.

Plant distribution

I should like to suggest another reason for the depletion of plant species on the Gippsland Plain study area, particularly along the regularly-burnt railway line. Lunt stated that 'species that are common in grassy forest remnants must once have occurred in areas that are now cemeteries and rail-lines. This seems beyond debate: from soil data; from the close proximity of some grassy forest remnants to rail-line sites and from the improbability of finding these species time-after-time in small rail-line remnants.' (Lunt 1995). It is clear by their absence in this area, that current methods of land management, i.e. frequent burning, do not favour all species. Some have obviously been disadvantaged to the point of elimination!

It has been clearly shown by Lunt, that areas grazed by domesticated animals, where little or no burning occurs, have also disadvantaged many species. Indeed, evidence suggests that even occasional use by

these animals can have a marked impact on native flora (Archer 1984). Therefore, not only one method of management is at fault, but both, and each independently disadvantaging to the point of exclusion some indigenous flora and, quite possibly, others from both types of managed environments.

Ian Lunt proposed the following solution, 'if we want to save all of the species in grassy forest and woodland regions, we might consider re-integrating these two floras (from ungrazed burning ecosystems and unburnt grazing ecosystems), and one means of doing that maybe to re-integrate the major processes of burning and grazing, so that some parts of our big, intact reserves are regularly burnt and grazed (by kangaroos, not stock).' (Lunt 1995).

From over 25 years experience of almost daily contact with Macropod species, observations would indicate that their eating habits can be quite selective. I can vouch that certain Orchidaceae and other herbaceous species are highly regarded, and in the circumstances being discussed, this practice could adversely affect some plants, particularly in small areas. I therefore, question the rather rudimentary combination of two very inadequate management techniques, with the optimistic hope that kangaroos will somehow provide the missing link to stay the downward spiral of indigenous flora in grassy environments. I suggest the proposed solution is more likely to complicate matters and, in the process, inadvertently disadvantage species that have already indicated they cannot tolerate one, or other form of management.

The solution to the problem, I believe, revolves around the question of burning. This seems to be a commonly overlooked and misunderstood factor and one that has not been adequately addressed in relation to the grassy environments on the Gippsland Plain. If the real problems of Australia's indigenous flora and fauna are to be recognised, and conservation measures implemented, it is surely vital that the traditional methods of land management be examined in far greater detail.

Burning Practices

Few would contradict the extent of scientific evidence showing Australia's indigenous people commonly burnt grassy environments, and that a considerable portion of Australia's flora and fauna became dependent upon this practice. Gould used a quotation from the anthropologist, Norman Tindale, extracted from his 1959 paper published in *Mankind,* 'man probably has had a significant hand in the moulding of the present configuration of parts of Australia. Indeed, much of the grassland of Australia could have been brought into being as a result of his exploitation.' (Gould 1971). Neither Ian Lunt nor I seem to be at serious disagreement on these points, so if historic, scientific and general consensus support the use of fire to manage these environments and this has been the practice along the regularly-burnt railway line. Why have there been plant losses here! What went wrong?

I would contend it is not the burning, but the method of burning, that is the problem! What has been assumed is that fire always reacts in the same way and produces the same result. It need not! When dealing with such a complex, interrelated system as the environment, if you change just one factor, particularly one as important as fire, then you change the entire outcome!

Aboriginal Fire Management, or perhaps more accurately described as Fire-stick Management, was certainly, to most traditional aborigines, a particularly important function and on which their way of life was intricately dependent. So important, that to many it was allocated a special time of year, a season in which to burn, and was thus incorporated into their annual activities. To the first Australians, burning was no casual or spasmodic event, it was part of life itself. So what did these people do?

The Nyungar Aborigines of the Perth region of Western Australia, who were part of the Bibbulmun Aboriginal Nation, occupied the coastal area to a line extending south-west from about Kalbarri (approximately 450 km north of Perth), to the edge of the Nullarbor east of Esperance (approximately 700 km east of Perth). They selectively burnt from December to March. That was their Birak and Bunuru seasons. Usually from December to January there are hot, dry easterly winds during the day and south-west sea breezes in late afternoon; and from February to March hot easterly and north winds are the norm. (Bindon and Walley 1992).

The same Bibbulmun people, but from the south coastal region between Albany

and Esperance (Wudjari and Mineng Aborigines, Bates 1985), burnt later in the year, from March until early rains, which is usually the late April/May period (Hassell 1975). Normally strong winds subside at this time of year and are replaced by light breezes during the day, the nights are usually cool, still and dew laden (*pers. obs.*).

The Gagudju people of Kakadu, Northern Territory, begin burning during their Yeggee season (May-June), but do most during Wurrgeng (June-July)(Neidjie *et al.* 1986). In June-July, night temperatures may drop as low as 12^0 C. Light breezes dominate daylight hours, dropping at night when flames, now lacking a driving force, are extinguished by the morning dew (Neidjie *et al.* 1986; Breeden and Wright 1989).

In the spinifex grasslands of Central Australia a different strategy has been used and the management practices of the western desert aborigines are reasonably typical. They set fire to the spinifex at most times of the year for numerous reasons, but generally the more extensive burns with long term objectives take place October-December in anticipation of Summer rain (Gould 1971).

There are three important factors to be noted in the above examples:

1. Burning was an annual event, although this does not mean the same area was burnt each year.

2. Each Aboriginal group had a favoured time of year to burn. This would be influenced by the type of vegetation to be burnt and moisture content, plus current and impending rainfall. It would have been a major factor regarding fire intensity, and based on local conditions and aboriginal requirements, must have varied considerably both between, and within, regions.

3. The timing of these intense burning periods were also linked to reasonably predictable climatic events, which could be used to aid management and/or fire control.

My question is, were these factors taken into account when the railway land was burnt? Factor 1 certainly was not. According to Lunt, it was burnt about every 2–4 years. This is not only an important difference, it is a vital difference, capable of radically affecting bio-diversity.

To consider the differences between traditional fire-stick management and that used along the railway line, the outcome of these burning regimes need to be examined. To burn every 2–4 years implies a total or near total burn of the land area. With this method, all vegetation remains at the same level of development. This can disadvantage species that require a longer time frame in which to develop and reproduce, as it will also disadvantage those species with short-lived seed, that require open conditions to colonise '*Microseris scapigera* was found to have a transient soil seedbank, since virtually all seeds germinated rapidly, and no viable seeds persisted for longer than 3 months' (Lunt 1996). On the other hand, species advantaged will include those capable of rapid growth from either seed or regenerating root-stock, and/or those which can not only reproduce quickly, but also can provide reasonably fire-protected seed with some longevity. Plants of this description are likely to dominate resources such as space, light and moisture, and under these conditions further disadvantage slower developing species that do so exclusively from seed.

The traditional Fire-stick management would involve burning only sections each year so that a mixture of different aged vegetation would exist. This may, at first, appear a difficult position to achieve, particularly in grassland, but it must be appreciated that the conditions in operation in pre-European times were very different from those of today, and may require special attention in the current situation. Habitat area would obviously have been very much larger and consequently so would areas burnt, this would also allow greater leeway for natural factors, mentioned in items 2 and 3 above, to come into play. However, the most important considerations are:

A. With annual, widespread burning, fuel levels would be low, resulting in decreased fire intensity.

B. A mosaic of freshly burnt, young and developing vegetation would be in place, and anyone who has tried to burn green foliage full of sap, or dampened grass will tell you, it does not burn readily.

Therefore, unless a fire had hot, strong winds, and a high fuel load on which to

feed (which need not be the case with this form of management), then fires could be of low intensity and reasonably self-regulating, to be extinguished once they came in contact with younger vegetation, and/or less favourable burning conditions.

From the perspective of the biota, an integrated, dissimilar aged vegetation system within any sized area, will provide a multitude of micro-habitats, from open freshly-burnt zones ready for colonisation, through to mature plants that, owing to the mosaic pattern of burning, flames have either bypassed, or not seriously harmed due to their low intensity. This environment now provides habitat for all types of vegetation, plus conditions for a myriad of animal life including those who pollinate the flowers, and/or distribute the seed, thus paying heed to an entire ecosystem. The uniformity of the railway line with its European (not traditional) burning regime, I suggest is grossly inferior, and biodiversity problems due to lack of habitat were bound to eventuate, as I also suspect will be the case with any adaptation of it.

The Aim

There is one more contributing factor that I should like to introduce, one which I believe to be the most important regarding indigenous fire management and this is the aim of management. This will set the guidelines and determine what action is taken; as can be gathered from the railway line management, this area was burnt, but the environment did not prosper even if some species did better than in the grazing/no burning zone. The most likely aim of the railways would have been to keep the track open and reduce the risk of fire, the welfare of the environment, I suspect, would have taken a very low priority!

As the railway management's aim would have been wrong for the environment, I should also like to suggest that any aim to improve conditions for currently disadvantaged flora or fauna by modifying the environment to specifically advantage them, is equally wrong! The problem lies with the complexity of the environment, one is not just dealing with a few individuals, nor hundreds, or even thousands, but millions of individual life forms, from micro-organisms to the tallest tree. It stands to reason that if a few individuals are favoured, many others, and some we know nothing about,

particularly their relationships and interdependencies, will also be affected and not necessarily to their benefit.

The solution to the environmental dilemma I proffer, is to strive for as healthy and diverse an environment as habitat will permit. To achieve this goal is to follow in the steps of those who developed a simple system many thousands of years ago, who by fire-stick management created a dynamic, inter-twined, inter-reacting environment via a multiple-aged vegetation complex. This method should considerably enhance the likelihood of providing a suitable habitat for a species one wishes to advantage, and most importantly, also provide favourable conditions for others of which we might be currently unaware.

A healthy environment must surely provide for the life it sustains, by the provision of food, shelter and suitable breeding conditions. I submit it can only do these things effectively with broad habitat diversity. A situation of uniform environmental conditions, as described, and with the modification proposed by Lunt, can, I suggest, only favour the few at the expense of the majority, with the result that disadvantaged species have, and will continue, to decline.

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From our Naturalist in Residence, Ian Endersby

Sons or Brothers ?

Lengthening daylight seems to be the trigger for many birds to start their breeding activities. This is, therefore, an important time for the field naturalist to remain alert as there are many observations yet to be made about the behaviour of Australian birds.

Upstream from Dight's falls, the Yarra River forms a large sweeping loop. Early one November morning a Dusky Moorhen *Gallinula tenebrosa*, in full breeding plumage, was seen on the bank breaking reeds and then swimming to give them to a mate to add to the nest that was being built under the overhanging branch of a River Bottlebrush. That was interesting, but worth little more than a passing note in my nature diary, until a second adult swam from the opposite direction with a contribution that it handed over to be added to the nest structure. The two birds then gathered floating weed material and one even draped a piece of plastic sheet to the side of the nest. Three birds in adult plumage co-operating to build a nest raises lots of interesting questions.

A week later one bird was re-arranging nest material and the two others swimming, one upstream and the other downstream. A fourth bird - which was greeted with sharp alarm calls - retreated, and the place where this occurred seemed to define one end of a territory comprising the large river loop. Shortly afterwards the bird left the nest and there did not seem to be any eggs at this stage. At the third weekly visit the nest was deserted and partially destroyed but there was a lot of Moorhen activity over about a kilometre of river: feeding, chasing, grooming, and mating. Nearly two months after the first observations two Dusky Moorhens were on the bank above the original nest site, feeding and grooming. A small, piping call revealed a juvenile with white under tail feathers, pink beak and no frontal shield, in the water, browsing along the bank underneath overhanging roots. It was joined by one of the adults from the bank and then a third adult came into view. We will never know if this was the original family. Stephen Garnett has described three

types of nest for the Dusky Moorhen; false nests, egg nests and nursery nests. False nests are built before the egg nest and then abandoned so it may have been a false nest that I observed, not one disrupted by a predator.

Australia seems to be the stronghold for bird species which exhibit co-operative breeding, particularly where young of one generation remain at the nest and assist with feeding the next. The only example that I could find in the literature for the Dusky Moorhen was a family of three generations being fed bread in the Botanic Gardens lake. An adult passed bread to a juvenile which gave some to another juvenile and they both then fed it to downy chicks. Similar observations have been recorded from the shores of Lake Burley Griffin where birds are regularly fed. A related phenomenon is the breeding group, well documented for the Tasmanian Native Hen *Gallinula mortieri* and also for the Dusky Moorhen where a number of adults are involved in guarding territories, raising young, and perhaps even contributing to the actual breeding.

The breeding unit of the Tasmanian Native Hen often consists of a female and two males which are brothers and this example is used to demonstrate the phenomenon of kin selection. Because a nephew or niece carries on average a quarter of your own genes it is better to help raise that child than to bear none of your own. Similarly, for young helping at the nest, a sibling of the next generation carries about half of your genes and so ensuring that it survives is a good strategy if you cannot produce descendants. Kin selection is one of a large number of alternative hypotheses that have been proposed to explain helping at the nest but it has been demonstrated only rarely. The Tasmanian Native Hen is a possible example but the Dusky Moorhen is not; members of its breeding group are usually unrelated and there is no genetic payoff in raising other people's children.

Two concepts are getting a bit muddled here; hence the title to this note. The first

is polyandry where adult brothers (or polygyny for adult sisters) are part of the breeding group and may or may not be involved in mating. "Helpers at the nest" was originally coined to describe immature birds assisting with the raising of the next generation. Each of them needs a theory that explains the benefit to the individual because I am not prepared to accept altruism or group selection as being the driving force. It does get particularly hard if the birds are not related so we are left with suggestions such as the serving of an apprenticeship, paying rent for use of the territory, or, for adult males, 'believing' that they are the true father. Perhaps it has nothing to do with selection pressures but results purely from reactions to particular stimuli. I look forward to the ongoing debate.

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A Naturalist's Reminiscences

'A pinewood is an ideal place to live in due to the antiseptic and medicinal qualities emanating from the trees.' So wrote W.H. Hudson, an English naturalist who lived about the turn of the century. Hudson himself really preferred woods with more open space, where he could see the birds and other wild things. but he admits that as the virtues of the pinewoods were realised, large and ornate homes sprang up in their vicinity like colourful toadstools. Important persons could thus enjoy the healthy atmosphere! Do we in this country appreciate the health-giving properties of our introduced pinewoods or is it the equally antiseptic qualities of our eucalypt forests that attract the large and ornate homes?

Hudson noticed the number of ant beds among the pines. Some trees bore streams of ants both going up and coming down. He wondered if the ants ever overwhelmed nestling birds or attacked those in hollow stumps, but he had never seen or even heard of such predation. Later on, we find that Hudson, who was probably a teacher, found some evidence in a small boy's essay that suggested that nestlings are sometimes killed by ants. Then he himself discovered four wren chicks dead in the nest but still warm, swarming with small red ants. His conclusion was that small birds fear the ant columns and will avoid infested trees for nesting. He suspected that the ants favoured certain trees only, and left others alone. Another school essay described a skylark's nest with dead chicks smothered with ants.

I have never come across such a thing and on inspecting my trees found ant trails only on one Spotted Gum. Charles Barrett, a Melbourne naturalist, who had read Hudson's book 'Life in a Pinewood', corresponded with him. Barrett believed that numbers of nestlings here fall victim to ants. Any comments from our birdos?

Ellen Lyndon
7 Steele Street, Leongatha, Victoria 3953.

Ellen came across this interesting snippet in a handsomely bound book in Jean Galbraith's library.

Malleefowl Eating Fungi and Orchid Tubers

Introduction

One of the authors (W.R.) has been watching Malleefowl for many years in captivity at Little Desert Lodge and in the wild at a block of remnant mallee/broombush near Nhill. One pair (dubbed Charles and Di) have become so used to his presence that he has been able to follow them through the bush, filming and observing at close range their feeding and other behaviour. In 1995 he filmed both birds on a number of occasions pecking at and eating what appeared to be fungal fruit bodies. Sometimes the whole cap of the fungus was removed and eaten. The birds were also observed eating what appeared to be orchid tubers. Malleefowl are known to eat various plant parts (including tubers) and invertebrates, and there are occasional reports of fungi being included in their diet (Benshemesh 1993). The fungi and tubers involved have not so far been identified, and consumption of these food items is rarely recorded for birds. In their comprehensive list of the foods of Australian birds Barker and Vestjens (1989-1990) list only one occurrence of birds eating fungi (by the White-Plumed Honeyeater), and one instance of consumption of orchids (by the Pied Currawong).

Fungi

From an inspection of the films taken of the Malleefowl it was not possible to identify to species the fungi which they were pecking at, but in at least one case the fungus was clearly a small orange-brown agaric, possibly a species of *Laccaria* or *Cortinarius*. An opportunity to identify the fungi arose in April 1996 when on two occasions Charles was sighted pecking at and eating small brown agarics. The remnants of the fungi were retrieved and preserved. At around the same time fresh droppings (from Charlie) and dried droppings from the area in the which the fungi were found were collected and preserved in 70% ethanol.

The two agarics were the same species and appear to belong to the genus *Paxillus*, although fruit bodies were smaller than is usual in that genus. The cap was up to 18 mm in diameter and yellowish brown to yellow in colour, the gills were decurrent and brown with a paler edge which was finely serrate. The fruit body was about 10 mm high, with a central stem to which the gills were attached near the base, the spores when viewed at high magnification under a microscope were pale yellowish brown, ellipsoid in shape and 8–9 x 5–5.5 microns in size. Similar spores to those of these fungal specimens were also detected in the samples of droppings.

In the drier areas of north-west Victoria which are the home of the Malleefowl the production of fungal fruit bodies is sporadic and good fruitings occur only after suitable rain. Further observations at times of abundant appearance of fungal fruit bodies are required in order to establish how important fungus consumption might be to the Malleefowl and also what suite of fungi are eaten.

Orchids

In November 1994 Charles and Di were observed to dig up some spherical objects from near the base of a Moonah *Melaleuca lanceolata*. Some samples were placed in a pot of soil and some months later leaves appeared which were typical of the genus *Pterostylis*. At the same time, at the spot where the birds had been digging, a colony of Greenhoods *Pterostylis* appeared. The potted tubers later flowered and were identified as Dwarf Greenhood *Pterostylis nana*.

Again, further observations are required to determine how much tubers might contribute to the diet of Malleefowl, and what different orchid species might be consumed.

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Carrion Feeding by a Common Brushtail Possum
Trichosurus vulpecula on Flinders Island

The diet of the Common Brushtail Possum *Trichosurus vulpecula* consists primarily of leaves from trees and shrubs, with grasses, fruits, flowers and bark also eaten (Fitzgerald 1984; Kerle 1984). Meat is sometimes consumed by captive animals, but is eaten only rarely in the wild (How and Kerle 1995). Individuals have occasionally been observed catching insects (Murray 1977) and birds (Anon 1935; Morgan 1981). Carrion feeding by the Common Brushtail Possum has been reported from the introduced populations in New Zealand (Gilmore 1967).

On the Australian mainland the Common Brushtail Possum feeds mainly in trees and shrubs, while in Tasmania (including Flinders Island), it tends to be more terrestrial, and often forages on the ground (Watts 1987). In wet sclerophyll forests in Tasmania over half of its food, mainly soft-leaved dicotyledons, is taken from the ground (Statham 1984).

On Flinders Island, 4 May 1994, half-an-hour after dusk, I observed a Common Brushtail Possum at the carcass of a Tasmanian Pademelon *Thylogale billardierii*. The Pademelon was on the side of a minor road and appeared to have been killed by a motor vehicle. The possum was actively tearing into the viscera of the Pademelon through an opening on the ventral surface. Its head was often completely immersed in the body cavity, and it repeatedly tore pieces out by jerking its head back. It remained at the carcass for approximately 20 minutes, until I disturbed it while trying to take a photograph. On leaving the carcass the possum crossed the road and moved along a well-worn path into a large, introduced, prickly shrub which it appeared to be using for shelter. The surrounding area was cleared farmland with very few trees, although coastal vegetation was nearby.

I examined the carcass the following morning and all the organs, including the intestines, had been removed. The exposed leg muscles, however, were untouched. Tasmanian Pademelons feed mainly on soft grasses and herbs (Johnson and Rose 1995) and, assuming the animal was a road-kill, it is likely that there was food in its stomach and intestine. The possum may have been attracted to the carcass by the plant material contained in the intestine of the Pademelon. However, other organs had also been consumed.

Carrion feeding on whale meat, deer carcasses and dead possums has previously been reported for the Common Brushtail Possum in New Zealand (Gilmore 1967). Many of these observations were made when the possums were in very high densities and in poor condition because of depleted habitat. It has, however, to my knowledge, not been reported before in Australia. On Flinders Island, where there are a high number of macropod road-kills and no foxes acting as scavengers, carrion feeding by the Common Brushtail Possum may occur more often than elsewhere in its Australian range.

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Healesville's Nightlife Exposed

For over two years, we have had the opportunity to visit at night the beautiful Badger Weir Park, Healesville, and have kept records of the animals seen and heard during our spotlight surveys. Until recently, this park was managed by Melbourne Parks and Waterways and Melbourne Water. However, as of December 1996, the park is within the new Yarra Ranges National Park, and will be managed by these authorities as well as the Department of Natural Resources and Environment. The park is a naturalist's paradise and well deserves the increase in status that the new title will provide.

When one arrives a few hours before dusk, it is not unusual to be greeted by Crimson Rosellas, Sulphur-crested Cockatoos, Common Bronzewings, Pied Currawongs, Laughing Kookaburras and the occasional King Parrot hoping for a free feed. Gang-gang and Yellow-tailed Black Cockatoos are often seen and heard overhead as they select their roosting places for the night, and sometimes Galahs and Little Corellas make an appearance. In the background one hears the calls of the Yellow Robin, White-throated Treecreeper and the Superb Lyrebird. As the sun sets, these animals retire into the surrounding bush and we prepare for our evening stroll.

Our starting point is usually near the base of a magnificent Manna Gum. Nearby, the Southern Boobook Owl is the first to announce that it is awake, closely followed by the shriek/gurgle of the Yellow-bellied Glider. Most evenings around fifteen minutes after dusk, a pair of Greater Gliders leave their hollow in the Manna Gum and make a spectacular glide over our heads to commence their foraging in the mixed species forest upstream. On one notable occasion in October 1995, the female did not glide, and was observed to be carrying a juvenile on her back. This youngster has been seen leaving the nest tree with its parents up until August 1996.

Over the next two hours we experience the sights and sounds of the many animals and plants which make the park so special. The Boobook Owls breed regularly and we have recorded the rare Sooty Owl breeding here every year since we commenced our walks in January 1994. We have also heard adult Powerful Owls and seen one juvenile, and although we have seen and heard adult Barking Owls, we have yet to determine if they are breeding within our walk area.

As we make our way up to the weir, which channels water from Badger Creek to Healesville and Silvan Reservoir, we see in the Mountain Ash several more Greater Gliders. Most of these have dark fur, but we also walk through the territories of three which have pale grey/cream coloured fur. In summer, the Owlet Nightjar is often heard calling after dark, and male lyrebirds are heard vocalising after dark at all times of the year. We have recorded Short-finned Eels in the rock pools, and an Eastern Water Rat swam downstream one evening.

During December 1995 and January 1996 we sighted a Leadbeaters Possum on several occasions, and have yet to determine if this represents a permanent territory. A Platypus is often found feeding in the weir, for this has created a deep pool in which silt gathers, and we are indeed fortunate if we get more than one look at this elusive creature.

On the way back to the picnic area, we walk beside the aqueduct which is home to a large number of Brown Trout. Often Swamp Wallabies and a Common Wombat will be grazing on the cleared area here and after a hot day we may even see a Tiger Snake partly hidden in a rock wall waiting for supper. Mountain Brushtail Possums (Bobucks) share this drier mixed species forest with the Common Ringtail Possum, Greater Glider, Sugar Glider and Yellow-bellied Glider and even the wary Sambar Deer, fox and feral cat have been seen.

By the time we have completed our circuit and returned to the picnic area about one and a half hours will have passed. As little survey work has been done in these parks on a regular basis, we anticipate that our records will gain valuable information for the managing authorities and those who have an interest in our native forests.

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WETLANDING

Specialising in wetlands gives the Field Naturalist the chance to be involved with one of our most varied ecosystems, from montane lakes to mangrove swamps and, in between, shallow ponds, peatlands, salt marshes, coastal lagoons, freshwater marshes, deep permanent lakes, salt lakes and billabongs.

Activities:

The area where land meets water is rich in diverse life forms and wetlanding opens up opportunities for a variety of interests including:

- studying the various ecosystems
- watching waterbirds at close quarters
- frog watching and listening
- discovering the less flamboyant, but equally beautiful, plants such as aquatic herbs, grasses, sedges and rushes
- exploring the aquatic life
- photographing scenes of unusual colour and texture combinations
- conserving and revegetating particular wetlands, or
- simply wandering in quiet, tranquil places

Whatever your particular interest in wetlands, keep good field records of each visit including notes on the type of wetland, vegetation, approximate water depth, bird, frog, insect and human activities. Also note management issues and/or any other comments that may be helpful to pass on to Department of Natural Resources and Environment or other bodies interested in, or responsible for, wetlands.

Once begun, wetlanding can become a focus for any day trip, weekend jaunt, annual holiday or long service leave (whether in Australia or overseas). But remember to tread carefully for your own safety, and tread lightly to protect the environment.

Equipment:

General - gum boots, field glasses, 10x magnification hand lens, camera, field notebook, appropriate field-guides of your particular interest - and mosquito repellent.

PERMITS ARE NEEDED TO COLLECT, except on private land (where permission is needed). For collecting specimens from the water you will need a long handled dip net, a grapple for collecting plants, a shallow white tray and specimen containers. Keen wetlanders buy waders and/or a small flat bottomed boat to explore the wonders of wetlands not visible from the edge.

Clubs and Societies

Victorian Wetlands Trust Inc. (wetland information, regular visits and newsletter).
Coast and Wetlands Society Inc., NSW. (newsletter, wetland visits - mainly NSW, and a Journal)

Newsletters and Journals

Wetland Ways, Newsletter of Victorian Wetlands Trust Inc.
Wetlands (Australia), Journal of the Coast and Wetlands Society Inc., NSW
Wetlands Australia, Newsletter of the Australian Nature Conservation Agency

Field Guides and General References:

Australian Waterbirds, A Field Guide, Richard Kingsford (Kangaroo Press Pty. Ltd., NSW) 1991.
Australian Wetlands, A.J. McComb and P.S. Lake, (Angus and Robertson, Aust.) 1990.
A Directory of Important Wetlands in Australia, (Australian Nature Conservation Agency, Canberra) 1996 Describes approximately 700 important wetlands - definitely not a field guide, but invaluable for the serious wetlander
Explore Melbourne's Wetlands, Sid Cowling, (National Trust, Victoria), 1991.
Freshwater Invertebrates, Ralph Miller, (Gould League) 1996.
Waterplants in Australia, A Field Guide, G. R. Sainty and S.W.L. Jacobs, (Sainty and Associates) 1994
Wetlands in Danger, Mitchell Beazley in association with IUCN - the World Conservation Union (Reed International Books Ltd., UK) 1993.
Wetlands Wildlife, The Nature of Wetlands in Southern Australia, Sid Cowling (Gould League)

Enquiries:

Your FNCV contact for Wetlanding is Dr Kathleen Ralston, 1/79 Stanhope Street, Malvern, 3144. Tel. (03) 9509 4390 or Breamlea (052) 641291.

Kathleen Ralston

The Wombat
Common Wombats in Australia
by Barbara Triggs.

Barbara Triggs first accepted the responsibility for a wombat in 1976, when she was given a young orphan to care for. She soon discovered that information about wombats was a rare commodity. So she set herself the task of finding out how a wombat lives in the wild, and along the way found a love affair with those most beguiling beasts. As others had before her, she took wombats into her home and life - or rather, they took her! Caring for a wombat does mean sacrificing one's own life, at least in part. No conventional 'pet', a wombat. As demanding of time and love as any human baby when small and somewhat overpowering when adult, sharing your home with a wombat is not for everyone. Barbara's special capacity as a wombatophile comes through in this revision of her 1988 landmark book. Her dedicated field work, coupled with her obvious delight in wombats is brought together in an eminently readable fashion, the text enhanced by the many excellent photographs and Ross Goldingay's sensitive and accurate drawings.

Chapters 1 and 2 deal with the evolution, classification and distribution of wombats. Of the giant Pleistocene wombats, *Phascolonus gigas* was the biggest, more than twice the size of modern wombats, and much more widely distributed than wombats of today. Perhaps we should be grateful that they are no longer with us. Having one of them sharing one's house might be a bit overwhelming. Intriguingly, there are no fossil wombats reported from Tasmania, although that State is now a stronghold for Common Wombats.

I would have liked some revision of the maps, as well as of the text: 'Mammoth' is still missing from the cave identifier on Figure 1.1; and showing the former distribution on Figs 1.7 and 1.8 would have been helpful, especially to remind readers that wombats have been exterminated from a substantial part of their range in western Victoria, at least.

The type specimen of the Common Wombat came from Preservation Island, one of the many small islands off Flinders Island. And wombats are as much of the high country and the coasts as they are of the forests, but that is a minor criticism.

The description of the wombat (Chapter 3) is clear and concise - a brief note that the effects of sarcoptic mange may markedly alter the appearance of the coat could have been included here, although the issue is graphically covered in Chapter 8.

One of my first readings about wombats was the account of burrow exploration by Peter Nicholson, at Timbertop. It still remains one of the most fascinating stories among wombat lore, and furnishes us with a real wombat's eye view of home. Whatever happened to Nicholson? John McIlroy's detailed study, Nicholson's observations and Barbara Triggs' own experience enable her to provide an almost claustrophobic description of the varied excavations that a wombat calls home, and the daily events that occur therein. The day (or rather night) in the life of a wombat is evocatively sketched in Chapters 4, 5 and 6. I was particularly taken with the descriptions of grooming, having myself marvelled at the control exercised by that marvellous hind foot. No other animal can scratch in quite that way, and it is particularly astonishing in one of such outwardly ungainly form. Mind you, when young, balance is not always achieved! Ross' drawings are particularly apposite as accompaniments to the splendid writing.

Often the only evidence we see of the presence of wombats in the bush are the characteristic scats, perched on a rock or fallen log. Clear markers, these. And ample evidence of the dietary tastes of a wombat. But why do wombats not urinate lots? Other herbivores do so. Another question for researchers to ponder.

The well-written account of growth and development of a wombat (Chapter 7) enabled this former wombat foster parent

to relate very closely, particularly to the descriptions of play and first experiences in the wide world. Even a surrogate. human 'mother' evokes these responses, and dependence can be a real trial at times. A wet, dirty youngster, straight from burrowing practice is not always welcome at close quarters.

Despite their size and strength, wombats are as vulnerable to the 'dangers, disorders and disasters' of the world as other animals, and Barbara Triggs shows us how some of these events can affect a wombat. Even the burrow is not always the haven one might imagine, be the danger fire or predator - or man. Reminded of *'The Death of a Wombat'* by Ivan Smith and Clifton Pugh, I felt uneasy at the fate of wombats subjected to a raging bushfire.

That humans are a wombat's worst enemy cannot be doubted. Attitudes towards them have certainly changed in recent years, but the tale of their virtual extinction in parts of their range, and the almost fanatical persecution in other parts does not make for comfortable reading. Recent research has demonstrated that the claims of damage have often been over-estimated, but the bounty system that operated until the late 1960s (in Victoria, at least) was responsible for much unwarranted wombat slaughter. Some enlightened land-owners are now trying to share their world with wombats, but the conventional carelessness towards them is still apparent in many country areas. It needs more than just a change in legislation to convince some humans that wombats are just as much a 'cuddly little Australian' as their cousin the Koala.

The final chapter in the book deals with rearing and relinquishing orphaned wombats. Barbara's personal experience is manifest in the sympathetic way in which she reveals the pitfalls and joys of having a wombat in the house. Having been there and done that, I can vouch for the accuracy of the experiences recounted here. A properly wombatted house is never quite the same as it once was! But the real value of this part of the story is to be found in the careful analysis of ways to return a wombat to the bush, and an indication that this part of the exercise is often every bit as difficult as the actual rearing. Without taking this step, however, one might as well not take the orphan into care at the start.

Two useful Appendices, charting growth and development and tips for would-be wombat fosterers, a good reference list, and an excellent index combine with the comprehensive text to make this a most useful, as well as entertaining. book.

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Meteor Showers

People like me will always look up to the sky at night to see if there will be a 'shooting star' - a meteor. There are also the people who know that there are times when meteors are more certain. That happens when the Earth passes through congregations of meteorites, which it does repeatedly every year. The times are:

January 4	Quadrantid shower 40/hour maximum,
April 22	Lyrid shower 15/hour maximum,
May 4	Eta Aquarid shower 20/hour. maximum,
July 28	Delta Aquarid shower 20/hour maximum,
August 11	Perseid shower 50/hour maximum,
October 21	Orionid shower. Dust from Halley's 25/hour maximum.
November 2	Taurid shower 12/hour maximum,
November 17	Leonid shower 15/hour maximum but swift,
December 14	Geminid shower 50/hour maximum,
December 22	Ursid shower 15/hour maximum.

Those are the days of the best chance. two or three days either side will still give you a good chance. The best times are from midnight to 4am.

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Wildlife and Woodchips
Leadbeater's Possum - A Test Case for Sustainable Forestry
by David Lindenmayer

Publisher: *University of New South Wales Press, 1996. RRP $34.95.*

Reading David Lindenmayer's book, I found myself constantly reminded of renowned zoologist and environmentalist, the late Peter Rawlinson. It was Peter who, along with Peter Brown and other colleagues mentioned in the book, and using hard-won factual information, first brought into stark public focus the ecological dangers implicit in clear-felling and over-utilisation of Victoria's mountain forests. Such exploitation, he argued, was not only indefensible in the broad economic perspective, but was destructive beyond reason to the State's biodiversity assets, and to Leadbeater's Possum in particular. This book is proof of the extraordinary resolve which David Lindenmayer, like Rawlinson, has exhibited in pursuit of improved government policies for the management of Victoria's montane ash forests.

Dr Lindenmayer has transformed a potentially daunting complex of political and ecological issues into a clear, logically-organised, and highly-informative compilation. The book serves primarily as a case-study for Leadbeater's Possum, but scans more widely the issues of forestry effects upon native fauna – possums and gliders, in particular. In a very readable style, the author first provides basic details of the evolution and present status of the relevant species, their life-history, behaviour and habitat needs, and how they can be studied. Many common-place queries (for example, why nest-boxes cannot be viewed as a practical alternative to large hollow Mountain Ash trees) are addressed. The book then progresses logically to the impacts of logging, dealing extensively with the limitations of clear-felling as a substitute for natural ecological processes (such as wildfire). Finally, and most importantly, the book explains the urgency of change needed in the present forest management approach, and provides many recommendations on how these changes can be achieved.

An important feature of the book is the extent to which it acknowledges the value of many of our existing forest management strategies and attempts to demonstrate how a true and lasting conservation outcome can be achieved by enhancing and supplementing these strategies. The balanced attitude of the author is particularly admirable, given the graphic examples of destruction of prime Leadbeater's Possum habitat (and even of blatant contravention of habitat protection guidelines) witnessed by Dr Lindenmayer and depicted on various pages. A number of observations made in the book should be of major concern to responsible policy-makers at the highest levels of government. These relate to government capacity to plan and supervise environmentally-sensitive harvesting operations, the role that pulpwood (rather than sawlog) production still plays in 'driving' the forest management process, and the inflexibility of government policy options as a result of resource commitment under long-term harvesting licences.

The book is a stimulating blend of theoretical and practical aspects of forest ecology, both aspects being extensively illustrated through charts, tables, figures, lists of summary points (very useful) and colour photographs. Also included is considerable historical information (for example, a list of the largest recorded veteran Mountain Ash trees). Field naturalists may particularly relish the section on field research methods, which explains the current range of mammal detection techniques, their uses and limitations. This section is accompanied by much interesting factual and anecdotal information, clearly the legacy of an author who has had extensive field experience and long familiarity with the topic. Despite the complexity of statistical analyses behind many of the concepts outlined in the book, the presentation is generally clear, straight-forward and easy to absorb.

A number of short-comings in the book warrant mention. Although the book incorporates the Leadbeater's Possum case-study within a more general discussion of the montane forest environment, the integration is somewhat superficial, giving the impression that the two theme lines have been melded together only in the final stages of the book's production. The text fluctuates rather erratically from a single focus on Leadbeater's Possum to more general environmental sub-topics. While this in no way detracts from the value of the information and concepts presented in the book, it tends to distract the reader by undermining the cohesion and flow of the text.

I found captions accompanying figures and tables sometimes too cursory to explain clearly the information being presented. In addition, one or two predictable avenues of discussion seem to have been overlooked.. For example, the author details a number of 'non-ash' habitats in which Leadbeater's Possum naturally occurs (or occurred), including at Yellingbo, Bass River, Mt Baw Baw and Lake Mountain, but does not elaborate on the relevance (or otherwise) of these *alternative* habitats to the present distribution of the species, overall.

Also, readers should take particular care when interpreting the major (coloured) map of the Central Highlands (Ch.1), as the superimposed outline of the Yarra Ranges National Park is scaled some 50% smaller than all other features. This places the entire Park seemingly east of Warburton (whereas it *should* extend as far west as Mt St Leonard), and thus understates considerably the area of known and potential Leadbeater's Possum habitat protected within park. One final irritation, which may be disappointing to those wishing to use the book as a springboard to other reference material, is the failure to record in the Bibliography (or list under the relevant chapter heading) a number of the references cited in the text.

Despite these blemishes, *Wildlife and Woodchips* makes a resounding contribution to the cause of securing the status of Leadbeater's Possum in its natural habitat, and will be found to be a valuable resource for foresters, wildlife ecologists, conservationists, amateur naturalists and students. alike. Moreover, *Wildlife and Woodchips* should be a mandatory item in the field kit of every manager of montane forests in Australia, and on the desk of every government officer involved in formulating policy for these forests.

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Roadside Geology, Melbourne to Ballarat

edited by Noel W. Schleiger

The geological history of our planet has provided, and continues to change, the tapestry over which the web of life has been superimposed. We can consider events on a grand scale, such as the movement of continents and the consequent impact on habitat change and biogeography, or on a micro-scale, such as the nature of the pore spaces in the soil developed on a basalt outcrop and the effect on root penetration by plant species. It is therefore, regrettable that basic geological knowledge of our world and environment is often lacking among the travellers on our roads and visitors to National and State Parks. I cannot think of a single reserved site that does not owe its existence to the geological history that produced it.

One of the greatest assets available to understanding the geology of an area is the very existence of road cuttings. These thin cuts into the earth provide a wealth of information on the local geology. But how often do we see them covered over with

green colouring, concrete or some cultivar species of plant (invariably without any justifiable engineering or safety purpose), as though we are ashamed to see the very fabric of the earth we live on.

It is a great pleasure then to welcome the publication of this volume on Roadside Geology as a joint publication of the two societies. This book contains a wealth of geological information on the area between Melbourne and Ballarat and is full of sketch geological maps, and colour photographs, supported by an informative text.

After the necessary preface and acknowledgements, the former including the essential note of caution regarding the observance of the rules of the road, the volume presents a review of the geology of the land between Melbourne and Ballarat. Small sketch maps are provided and essential terminology and a key to the maps are included in this section. Not only is the geological history of the land reviewed but the practical impact of the changing geology is highlighted with comments on agricultural land use and sources of raw materials for human activities. These comments serve to remind us that geology provides us with the resources, such as soil and aggregate materials, necessary for day-to-day living.

The next section of the volume consists of a detailed stop-by-stop description of localities in the form of an excursion guide. Detailed road directions are provided, usually with Melway map references for sites close to Melbourne, under the subheading "Where to go". These instructions are followed by the "What to see" information, again supported by photographs and additional sketch maps. The excursion concludes at Ballarat but is followed by a short chapter on the return trip to Melbourne.

The excursion guide is followed by a summary of the rock formations seen on the trip, and a table of the geological time scale showing the geological events demonstrated by the excursion. These are particularly useful.

The volume concludes with a comprehensive explanatory list of terminology and a list of further reading for those with a desire to learn about geology in general and the geology of Victoria in particular. The vol-

ume edited by Peck *et al.* (1992) could have been included within this section.

In these days of constrained budgets, it is always a battle between content and cost of production. The compiler of this volume, Noel Schleiger, and his co-authors are to be congratulated for achieving a good balance of text, explanatory lists and tables, maps, colour photographs and an attractive colour cover design. A few minor quibbles concerning the clarity of some of the sketch maps and some false colour production in a few of the photographs (eg. compare the front cover with page 28) should not limit the use of this book.

This book will be purchased by all those with an interest in local geology but it *should* be purchased by those who have not thought about geology and yet claim to be interested in the environment or conservation. Here is an excellent case for the conservation and management of road cuttings for the purpose of geological education.

The volume is a worthy successor to the delightfully written older works by Hall (1909) and Chapman (1929), long since out of print, but available in older libraries.

Well done!

References:

Chapman, F. 1929. 'Open-Air Studies in Australia'. (J.M. Dent & Sons Ltd.: London & Toronto).

Hall, T.S. 1909. 'Victorian Hill and Dale. A series of geological rambles'. (Thomas C. Lothian: Melbourne).

Peck, W.A., Neilson, J.L., Olds, J.R. and Seddon, K.D. (1992). 'Engineering Geology of Melbourne'. (A.A. Balkema: Rotterdam).

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Australian Birds of Prey

by Penny Olsen

Publisher: *University of New South Wales Press 1995;*
260 pages, 250 colour photographs; RRP $59.95

Penny Olsen has written 'Australian Birds of Prey' from an intimate knowledge gained during many years of caring for, and studying, diurnal birds of prey. The result is a book that will appeal to a diverse audience. On one hand, for readers with a generalised interest in birds, it presents a synthesis of knowledge on Australian raptors. On the other hand, for devotees of birds of prey, it contains a comprehensive bibliography and up-to-date treatise on their biology and ecology. It is particularly well illustrated with more than 250 colour photographs by some of Australia's best bird photographers such as Nicholas Birks and Lindsay Cupper. There are also more than 40 sketches and drawings, 20 graphs and 30 tables which supplement discussions in the text.

The book is organised into nine chapters. The introductory chapter discusses the characteristics of raptors and summarises the types of raptors found throughout the world. The second chapter introduces Australia's raptors and gives a brief description of each of the 24 species (18 accipitrids and 6 falcons) that breed here. The written descriptions include appearance, habitat, activity, size, weight and differences from similar species, and are accompanied by distribution maps, photographs and drawings for each species. Other topics covered in this chapter are evolution, relationships, names and nomenclature of Australian raptors. The third chapter is on raptor ecology and includes discussions on distribution, populations, movement and mortality. Chapter four covers diet, hunting and related topics while chapter five deals with various aspects of reproduction.

The sixth chapter discusses the health of Australian raptors including the effects of pesticides, poisons and parasites. Penny Olsen has long had an interest in pesticides and their impact on raptor populations in this country. In the 1970s and early 1980s she was one of the few voices sounding a warning about the presence of the organochlorine pesticide, DDT, in the Australian environment. Unfortunately, her concern was realised in 1987 when Japan and the United States banned imports of Australian meat because of contamination by DDT and dieldrin. Soon after this occurred, both of these pesticides were banned for use on farms in Australia. This chapter contains a well-written summary about how DDT induces eggshell-thinning, resulting in embryo deaths in raptor populations.

Chapter seven discusses the study of birds of prey, and explains how to conduct surveys and food studies, as well as how to trap, handle and mark raptors. The penultimate chapter examines the relationship between raptors and humans and the last chapter is on conservation, which the author defines as any measure that helps to ensure the well-being and long-term survival of wild raptors.

In summary, this book contains a wealth of authoritative information on raptors which is presented in a readable and interesting fashion. In particular, I believe that it will make raptors more understandable to those people who, in the past, have viewed birds of prey as either uninteresting or distasteful. I highly recommend this book as an important reference for anyone with interests in learning about, conducting research on, and understanding Australia's birds of prey.

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Nourishing Terrains:
Australian Aboriginal Views of Landscape and Wilderness

by Deborah Bird Rose.

Publisher: *Australian Heritage Commission; R.R.P. $16.95.*

All readers of *The Victorian Naturalist* are interested in aspects of our natural environment and most would be concerned about its conservation.

'*Nourishing Terrains*' is a short, timely and valuable book on the Aboriginal perspective of living in, and being a part of, the Australian landscape. The Aboriginal world view is presented as a coherent and cogent whole of immense value to 'settler Australians', as the non-aboriginal Australians are described.

Rose uses poetry and songs to illustrate and analyse the perspectives that "settler Australians" need to be re-exposed to, and which perhaps in the longer term can be adopted into the national culture. Through selections from published and field collected works, the concept of 'country' - belonging and caring for it - is developed as the central theme. This is encapsulated in the simple, yet profound, observation: 'Nothing is nothing'. In the words of April Bright, 'If you don't look after country, country won't look after you'.

These perspectives are also supported by the observations made by pioneers. When Dame Mary Gilmore asked her father about the decline of the fish in the rivers, the response was 'when the blacks went the fish went.' Rose is able to fuse a pleasing convergence of history, ecology and philosophy into a readable account which is not without its polemic.

'*Nourishing Terrains*' examines many cultural dichotomies. Between perceptions of 'wilderness' and 'cared for country' the fundamental gulf between philosophies of aborigines and the 'settlers' is exposed. Viewing an eroded landscape in the Victoria River district prompted Daly Pulterara to observe: 'It's the wild. Just the wild.' In contrast, cared-for country was extensively 'fire-stick farmed' to enhance it productivity. Now, Rose says, inappropriate fire regimes of the settlers caused 'the country' to become 'sick'. Rose

argues quite persuasively that, as the evolution of our ideas on the ecology of the Australian landscape draws us closer to some of the practicalities of aboriginal land management of the continent, there is space for increased understanding. Land management is a central problem for settlers stemming from our perception of the landscape.

A few mistakes in the book detract a little from the very positive central argument. (Claiming that the First Fleet was responsible for the rabbits in Australia is a mistake of timing that's out by a couple of generations.) But the major criticism of '*Nourishing Terrains*' is the impression, left with the reader, that the Aboriginal occupation was a golden age of land management. The aborigines did 'eat a bit of their future', but this aspect is not fully explored by Rose. This neglect has the capacity to inhibit the synthesis of the opposing outlooks.

Our history - our place in the landscape - is being re-interpreted and the view of those with the deepest knowledge and understanding is critical and valid. This is Rose's contribution. Readers that have included '*Edge of the Scared*' or the '*Road to Botany Bay*' in their browsing diet will find that Rose's book teases out a lot of the issues raised in the re-examination our perceptions of being 'here'. The additional perspective is welcome.

In our 'reconciliating' the sense of guilt about the brief European history is probably married to a subconscious knowledge that the Aboriginal view of the landscape may be far richer and, in the long term, more sustainable than our Western materialist view. This book examines the space between blame, guilt and hope. Perhaps as non-aboriginal, post-Mabo Australians, move from being white 'settlers' to becoming 'settled' Australians, this book will become essential reading. Although some may find this book confronting, the Australian Heritage Commission is to be

congratulated for its publication.

> *'I've kept it in my mind,*
> *and now whenever there's a wind blowing*
> *I get a stabbing pain*
> *right through my eyes.*
> *What's happened to all the people?*
> *What's happened to all the people?'*

Victorian Naturalist readers should enjoy this thought-provoking book about the essential challenge of living together in the landscape.

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Name That Insect
A Guide to the Insects of Southeastern Australia
by Tim New

Publisher: *Oxford University Press, 1996; RRP $59.95*

Australia has long suffered from the lack of a comprehensive, popular guide to its hugely diverse insect fauna. In the past forty years several simple guides and picture books have been published, but these have usually given only a few representative examples, and concentrated on the more spectacular insects - butterflies being especially well represented. But with probably well over 100,000 species of insects in Australia, naturalists have long needed a reasonably easy-to-use book with keys and descriptions that will help them identify any insect - to answer the basic question, 'What insect is that?' Tim New's latest book, *'Name that Insect: A Guide to the Insects of Southeastern Australia'*, is an attempt to provide such a book.

Tim is experienced both as an entomologist and as a writer. He has recently written an entomology textbook for university students, and a string of more technical revisions and descriptions of Australian insects; when it comes to animals with six legs, Tim New knows what he is talking about.

This new book follows a fairly traditional pattern; a general introduction to insect form and function is followed by a key to the identification of Australian insects, then descriptions of each class and order of insects which usually mention a few common or 'typical' species. This is the same basic structure as is found in the Australian entomologists' 'Bible', the two volume CSIRO magnum opus 'The Insects of Australia' (to which Tim New was himself a major contributor).

The key in Tim's book is accurate and reasonably easy to follow, although those with little previous knowledge of insect anatomy would need to refer frequently to the glossary, and the introductory chapters on insect structure. Accompanying the key are outline drawings of typical representatives of the major orders. It is both in the language and the diagrams that Tim New's book shows its greatest weaknesses. Tim has chosen to use the language of entomologists rather than more everyday language, and this may be off-putting for readers unfamiliar with this language. The drawings too, are more like those in a technical journal that a popular work. They are all either outlines or line drawings, and while accurate, are not immediately attractive.

For Australian insects are attractive. Not only our butterflies and moths, of which we have so many spectacular species, but our Dragonflies and Sawflies, our Stick Insects and Beetles, our Wasps and Katydids. And at a smaller scale, the delicate lace-like coverings of Lerps or the eyes of March Flies possess a beauty quite the equal of the most delicate fern or perfect feather.

With its relatively dry prose and lack of colour illustrations, Tim New's book fails to capture either the beauty or the fascination of Australia's insect fauna. However, as a key to identification and introductory guide, it performs its function well. It will be a useful addition to the growing number of books available to those interested in finding out more about our Australian insects.

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Backyard Insects

by Paul A. Horne and Denis J. Crawford.

Publisher: *Miegunyah Press at Melbourne University Press, Carlton South, 1996.*
232 pp., 128 colour photographs; RRP $24.95.

It is no longer necessary to rely on British or American publishers for good introductory literature on insects. Horne, the writer, and Crawford, the photographer, both have long experience in entomology in Victoria and have produced a book with wide appeal. The book is pitched at anyone who wants to know a little more about the insects that share our homes and gardens. It admirably fulfills the authors' intentions to allow a range of common urban insects to be identified and to show some of their interesting aspects.

'*Backyard Insects*' contains colour photographs of 94 insect species representing eighteen orders, plus six other invertebrate groups. Each double page spread has a colour photograph of the animal and a page of text including the common and scientific names, the size of the creature, the food it eats and other biological information. The material is presented in conventional taxonomic order, starting with silverfish and ending with the Hymenoptera.

The identifications in '*Backyard Insects*' appear to be accurate except the purported rove beetle (family Staphylinidae) is probably a species of *Carphurus* (family Melyridae). The photographs are generally of a high standard and include some excellent close-ups of very small species. All are of living animals.

Errors can be found in most every insect book and should be brought to the attention of the reader. Jewel beetles are protected in general by law only in Western Australia. It has not been established that larvae of these beetles 'usually live below the ground, feeding on the roots of plants'. Host plants of only a small proportion of the Australian buprestid fauna are known but it appears that the majority of species feed on the wood of branches or stems.

The simple, jargon-free, informal style of the writing has led to some over-simplifications and consequent inaccuracies. Male and female Dermaptera cannot be infallibly distinguished by differences in the forceps. The larvae of *Mnesempela* are really atypical for the Geometridae in that they possess all the ventral prolegs, so do not move like a normal looper. I have never before seen a reference to 'soldiers' of the honeybee. It is incorrect to call the pollen baskets (corbiculae) on the hindlegs of *Apis mellifera* 'sacs'.

The treatment of skippers (Hesperiidae) as a separate group to butterflies reminds me of the layperson's distinction between animals and birds. Skippers (Hesperoidea) may be distinguished from other butterflies (Papilionoidea) by a number of characters, however the possession of a hooked antennal tip is not a universal skipper character. Larvae of the group of butterflies known as browns do not generally hide under rocks and logs but rest on their foodplants or amongst ground litter. *Nyctemera amica* is known to fly during most of the year.

The closing pages of the book are valuable. Crawford has provided a useful four page summary of photographic techniques, while the end matter consists of a short glossary, a list of further reading and an index. Accuracy is most important at the introductory level because the earliest lessons are often the hardest to unlearn, so the glossary definition provided for 'haemocoele' should not be that for haemolymph (insect blood). Similarly, the term 'chrysalis' is normally restricted to the pupae of Lepidoptera, and the term 'larva' only applies to the immature stages of some insects.

One task of reviewers is to detect the defects in a work. Overall these are minor. '*Backyard Insects*' will be great for people without much entomological background, and for those with more expertise, it offers a considerable amount of new information gleaned from many years of observation and scientific study. Librarians should reject foreign offerings and choose the superior Australian product.

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Victorian Flora on CD-Rom

by Viridans Biological Databases.

Field Naturalists are well aware of our good fortune in Victoria in having very comprehensive information about what exists in the bush - both plants and animals. This new tool will help to make that information available much more readily. Viridans Biological Databases has used the State's Flora Information System from the Department of Conservation (that was) to develop this scientific and land management resource for use by ordinary people. It includes the 4500 Victorian indigenous and exotic plants, with photographs for about 1100, and detailed botanical text descriptions. You can obtain distribution information (by 270^2 km [approx] grids) about any plant for the whole state, or you can obtain a list of species for any part of the state.

Any plant's distribution can be overlaid with maps. There are nine themes to choose from, including soils, rainfall, topography, landsat imagery, land use at two levels of detail, and towns, roads and so on. For any plant you can search by Latin or common name. For many you can also access a good clear introductory photograph, then a more detailed set of three or four, with text description. These photographs are from several angles, to show different features, or show the whole plant in context. Plants are coded according to whether they are exotic or indigenous, and also by conservation status.

The quality of the maps, photographs and plant information is excellent. They are clear, well-coloured, the maps are beautiful and interesting in themselves.

I approached the task of assessing this wealth of information with trepidation. There were the usual technical preliminaries (taking half an hour to find a computer that would take the CD in Windows in the University library), but then I was able to navigate around the Data Base after about a quarter of an hour, and have since spent about three intriguing hours exploring the possibilities. I should add here that on both computers I used, the loading was very slow - up to two or more minutes for each plant. The information that comes with the package suggests that a high speed CD-Rom drive is best for this reason.

In making such a resource available to the general public, probably some cautionary note needs to be attached as to its use. It is not a replacement for a field guide in identifying plants, and is not organised that way. I'm told that this is a development being considered for a later phase.

What you **can** do is bring up a plant list, alphabetically, for an area, ideal for planning a field trip. It is easy to use the various map overlays to find and select the grids you want, although these are quite large in relation to the diverse range of human and natural features contained within any one grid, making it difficult to know which of the 606 plants in my local area would be found in the adjacent State park. I also found the common names facility a bit limited, not finding, for instance, the 'generic' common names such as 'pea flower', 'eggs and bacon' or 'orchid'. More specific common names are given, such as 'Tiger Orchid', but often these aren't very well known.

Plants aren't able to be listed by family, so in a case like the peas, where there are several possible genera, I was a bit frustrated by the lack of correspondence with the organisation of my Costermans, which, if it had been similar, could have helped to reinforce my meagre knowledge about how botanists group plants.

As a teacher of Environmental Studies, I looked at the data base for teaching pur-

poses. Could I use it for students to explore and find for themselves the correlation between distribution of various plants and factors which might explain that distribution? I found the possibilities here exciting for getting various broad general ideas across, although it was useful to have a little bit of knowledge of the names of some likely 'indicator' plants to bring out the significance of various factors. It was very good for establishing ideas such as the range of plants being very different, about the distribution of some weeds, about the plant communities particular to regions. It would be ideal for producing maps showing various particular relationships. Further research topics suggested themselves, based on more detailed back ground knowledge - the relationship between food or shelter plants and particular animals for instance. It would be very useful if Viridans were to develop some teaching material for the data base, as many teachers would not be aware of the useful questions to ask while using it.

Again, for some purposes the database is rather a crude instrument, because of the coarse size of the grid which indicates distribution. Any one grid may include quite a range of the classes in the feature being mapped, but the cross-hatching indicating the plant's distribution covers the whole indiscriminately, giving an impression that the plant would be found uniformly, regardless of locally specific factors such as valleys and hills, bush or farmland.

I rang Paul Gullan of Viridans to inquire about this. He explained the three main reasons for use of the 10 minute grid. It isn't desirable to give more precise information about some rare or coveted plants which may be protected by ignorance of their location. In some areas there isn't sufficient detail about many plants to effectively map more finely. Speed of access would be slowed down if there were even more detailed information available in the database.

These matters will be alleviated by regional systems which are currently being planned. So we have plenty to look forward to.

At $120 this is a very accessible proposition for libraries and resource collections. It will embellish courses in several disciplines. For botany students and teachers, in particular there are probably many other uses for the Data Base. Perhaps you are even now envisaging the possibilities for your next field trip, equipped with lists and so on for your site in advance.

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Mammals of Victoria
Distribution, Ecology and Conservation
edited by Peter Menkhorst

Publisher: *Oxford University Press, Melbourne 1995, in association with the Department of Conservation and Natural Resources;*
359 pages, colour and black and white illustrations, RRP $59.95.

This hardback book is essential reading for anyone with an interest in the distribution, ecology and conservation needs of all the 139 mammals recorded in Victoria.

The accounts of individual species are accompanied by high quality photographs and distribution maps based on the Atlas of Victorian Wildlife database. Eight well-known mammalogists from Flora and Fauna Branch of DCNR (now NRE) have contributed their expertise and the book takes in more than 30 years of work by a wide range of people from field naturalists to professional biologists.

Editors

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The
Victorian
Naturalist

Australian Natural History Medallion 1997

Geoff Blyth Monteith

The 1997 Medallionist is a man of great energy, imagination and enthusiasm for his chosen subject, entomology.

Geoff Monteith has been Curator of Insects at the Queensland Museum since 1978, where he has worked to promote interest in insects and to diminish the fear of them in the public mind. He has departed from the traditional practice of displaying dead specimens, and the Queensland Museum now shows living colonies of ants, giant burrowing cockroaches and phasmids. The historic insect collection of F.P. Dodd which he acquired for the Museum was developed into a major travelling exhibition entitled 'The Butterfly Man of Kuranda', which went on tour in 1991, visiting 19 centres in Queensland with Geoff Monteith giving a public lecture at each new venue. In 1994 this exhibition began a tour of New Zealand, where Geoff conducted a lecture tour. Another exhibition 'Living with Insects - Friends and Foes' was mounted in three galleries of the Queensland Museum, making it the largest insect event in Australia, which attracted some 75,000 people, including many school classes.

'Getting a Buzz from Insects', the workshops for teachers which Geoff set up proved so successful that they have attracted 1892 enrolments from 21 tours in Queensland and most interstate capitals. Recently eco-tourism operators have attended these workshops to acquire a basic knowledge of insects to pass on to their clients. Geoff has also coordinated the production of six educational loan kits which are available to schools. Public lecturing has included being the keynote speaker at three national conferences of the Australian Entomological society, and he frequently gives talks to community groups. His television work has included many segments on insects in Channel 10's children's program *Totally Wild*, and he has supplied live specimens and advice to 'Ranger Stacey' in Channel 7's *Cartoon Corner*. Geoff has assisted three British and two Japanese television crews in making documentaries on Australian insects.

Rainforest invertebrates are Geoff Monteith's chief interest, and he had led numerous field expeditions in Queensland, including 19 to the mountain summits of the Wet Tropics Zone of North Queensland. His extensive field work has resulted in approximately 500 species being named from his collections, and 106 species now bear his name. In addition eight new genera are based on his name.

Commitment to conservation is evident in the collation of insect information to support reservation of areas as National Parks, and the nomination of the Wet Tropics for World Heritage listing. He is compiling a Rare and Restricted Index of insect species for the Wet Tropics Management Authority, and a series of sites in Queensland for National Estate listing.

Geoff has published over 50 scientific papers, as well as reports and lighter articles, while his editing of the News Bulletin of the Australian Entomological Society greatly raised its standard, and for this he was awarded their Inaugural Service Award in 1994. His book, *The Butterfly Man of Kuranda - Frederick Parkhurst Dodd*, received the Whitley Award from the Royal Zoological Society of New South Wales in 1992, and he contributed chapters to *Brilliant Careers: women collectors and illustrators in Queensland*, published by the Queensland Museum in 1997.

Geoff is a long-time member of numerous societies, including the Australian Entomological Society, the Entomological Society of Queensland and the Queensland Naturalists Club, and has been President of the last two. In 1982 and 1984 he led extended expeditions for the Queensland Naturalists Club, and coordinated scientific observation by members, editing their writings for the *Queensland Naturalist*.

A very worthy recipient of the Australian Natural History Medallion, Geoff Monteith was nominated by the Entomological Scoiety of Queensland, supported by the Queensland Naturalists Club.

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The
Victorian
Naturalist

Editors: Ed and Pat Grey

Cover: Geoff Monteith, winner of the 1997 Australian Natural History Medallion (see article on inside front cover). Photo by Jeff Wright, Queensland Museum. The man in the background is Frederick Dodd, an important figure in early Australian entomology and immortalised as 'The Butterfly Man of Kuranda'.

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Is Dieback Declining?
The Threat of *Phytophthora cinnamomi*

Gretna Weste[1]

Abstract

Continued monitoring of permanent quadrats in diseased and in disease-free native vegetation in the Brisbane Ranges, the Grampians, and at Wilson's Promontory has demonstrated that 20-30 years after infection, the pathogen has a reduced population density and distribution. Highly susceptible plant species have regenerated on quadrats from which they had been eliminated, re-appearing, even in the presence of small pathogen populations. Possible explanations are discussed, including the likelihood of recurring cycles of disease and recovery. (*The Victorian Naturalist* 114, 1997, 216-221).

Introduction

In the 1920s dieback and death of Jarrah Trees *Eucalyptus marginata* were first observed in the West Australian forest. Nobody understood why, and the general conclusion of the Forests Department was that the trees were dying because of poor management. Dieback was only observed in areas where logging, construction or roading had occurred - in other words dieback was associated with man's intervention.

In 1965, more than 45 years later, Frank Podger, with the help of Professor Zentmyer from California, proved conclusively that the cause of the disease was a microscopic root rotting fungus-like pathogen called *Phytophthora cinnamomi* Rands, well known to Professor Zentmyer because it killed avocados in California (Podger 1965). In 1969 Frank Podger visited the Brisbane Ranges with Dr. David Ashton, Reader in Ecology at the University of Melbourne. He recognised the early signs of dieback in seven shrubs dying on the roadside, and collected samples. They were infected with *P. cinnamomi*. This was the first record of the disease in Victoria (Podger and Ashton 1970).

The pathogen was new to Australian vegetation, an overseas intruder, which in the wet season of 1970-71 quite rapidly destroyed up to 75% of the understorey of native species growing in Victorian open forests, woodlands and heathlands, and killed 45% of the number of stringy bark eucalypts such as the Brown Stringy Bark *E. baxteri*, growing on sites in infested forests or woodlands.

In 1970 we began to study this pathogen in the Brisbane Ranges, and attempted to prevent the disease spreading, but in vain. The swimming spores were spread by water

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from infested road gravel. Gravel taken from the originally infested area was spread along the road verges, and from the gravel tongues of infection spread into the forest wherever rain water ran off the road. The Brisbane Ranges were then state forest, and I persuaded the foresters to build a trench across the path of infection to which we added copper oxy-chloride. That weekend eight inches, >200mm, of rain fell in that area, and the swimming spores, undeterred by the poison, swam across the water-filled trench and spread disease right down the hill. We tried other treatments with varying success. Vapam soil injection not only killed the pathogen, but all the vegetation as well.

The pathogen spread along most roads. The soil was shallow, often less than 1m deep, and was a mass of roots, a feast for the root rotting *Phytophthora*. Some researchers decided that *P. cinnamomi* was native, a naturally occurring soil microbe, and that the obvious disease was due to man-made disturbance. We found differently and proved our view correct. We disturbed the soil, but no disease occurred. We added washed threads of *P. cinnamomi* to the soil and disease developed, and spread downhill with water. We re-isolated the pathogen thus satisfying Koch's postulates.

Dieback disease appeared in East Gippsland in 1972 and destroyed the Silver-top Ash *Eucalyptus sieberi* forests of the foothills, the precious timber that was to replace the Mountain Ash *E. regnans* destroyed in the 1939 bush fires.

In 1971 we found dieback at Wilson's Promontory. Bulldozers from East Gippsland were brought in on a low loader to assist with fire fighting at the Promontory. They were offloaded into an old gravel quarry on Five Mile road. Those bulldozers carried infested soil which they shed amongst the gravel. Gravel contains

little or no organic matter, hence few soil microbes. Because of this *P. cinnamomi* can survive for five years in gravel. The gravel from that quarry was distributed along the verges of the roads at Wilson's Promontory. From each small pile of gravel tongues of disease spread into the forest, woodland and heathland.

In the 1970s dieback was observed in the Grampians, particularly in the Victoria Valley. One of my students, Jill Kennedy, set up quadrats on six sites representing the six different plant communities in forest, woodland and heathland invaded by *P. cinnamomi* in the Grampians. We worked with the Forests Commission, as it was then state forest.

Dieback disease became widely distributed in Australia, particularly in the sclerophyll forests of southern Australia, but was also found in the Darwin region and in Queensland rain forest.

The progress of disease due to *P. cinnamomi* in the Brisbane Ranges, Wilson's Promontory and the Grampians was reported in detail (Dawson *et al.* 1985; Kennedy and Weste 1986; Weste 1981; Weste 1986; Weste and Ashton 1994).

Methods

We tested for *P. cinnamomi* by collecting a small sample (50g or 1/4 cup) of roots and associated soil from a living plant with symptoms of dieback. The sample was put into a plastic cup, covered with water and baited by floating eucalypt cotyledons or young lupin seedlings on the water. After three days the cotyledons or lupin roots were washed and dried and placed on agar medium containing antibiotics. Any *P. cinnamomi* present in the sample grew into the agar and was easily recognised. More recently tests were confirmed by immunological assays. There was so much pathogen in the samples that 1/250th of a sample from infested quadrats gave a positive test, but no *P. cinnamomi* was ever isolated from the disease-free quadrats.

The sites in the Brisbane Ranges, Wilson's Promontory, the Grampians and an additional site at Narbethong (now commercialised) were monitored biennially for the presence and distribution of the pathogen and for changes in plant species and their health or disease status. We set up a large number of measured plots or quadrats in diseased and in disease-free areas of each type of vegetation, and monitored them all. In each region we established a number of permanent quadrats on sites of open forest, woodland and heathland, for example on Syphon road in open forest in the Victoria Valley of the Grampians, there were eight infested and eight disease-free quadrats. These quadrats were studied either by direct observation, recording each plant, and whether diseased or healthy, or by point analysis. In the latter method, a rectangular grid was placed over the quadrat and each plant and its health were recorded on impact with a vertical wire pin, 64 pins to the quadrat. These methods enabled the measurement of vegetation changes, and of the susceptibility or resistance of each species.

Trees were measured visually on large plots, 30×30 m. Percentage crown damage provided the most effective measure.

All these measurements and the baiting tests were made in the last two weeks of May to reduce seasonal variations.

Results

From 1970 to the middle of the 1980s *P. cinnamomi* was isolated from 100% of the roots tested from infected plants, and from all quadrats on infested sites, but never from disease-free quadrats. Highly susceptible species were eliminated. Some less susceptible species showed symptoms of chlorosis and dieback, but some individuals survived. Infested sites were colonised by a dense growth of resistant species, such as the sedges, *Lepidosperma semiteres* and *Gahnia radula*, by Rope Rushes such as *Hypolaena fastigiata* and by teatrees such as *Leptospermum continentale* and *L. myrsinoides*.

After 1985, however, checks on the quadrats in the Brisbane Ranges indicated big changes, so in 1995-6 all quadrats from the three locations were re-examined. In previous biennial assays 100% of the baiting tests from infested quadrats yielded *P. cinnamomi*, but a change had occurred and 20–30 years after initial infection the pathogen became harder to isolate. There was a decline in the number of samples taken from infected plants which yielded *P. cinnamomi* from the Grampians, the Brisbane Ranges and Wilson's Promontory (Fig. 1). This demonstrated a decline in pathogen population density

There was also a decline in the distribution

of *P. cinnamomi*. We could not isolate the pathogen at all from some quadrats from which it had been readily isolated for the previous 20-30 years, for example from one plot in the Brisbane Ranges which had been infected since 1969, from Flat Rock Crossing in the Grampians, or from part of the Vereker Range at Wilson's Promontory. So there was a decline in pathogen population density and in its distribution on infested sites (Fig. 2).

While the pathogen declined on most sites (Figs. 1-3), some exceptions are evident from the histograms; for example, the pathogen was still frequently isolated at Millstream Creek in the Grampians, at the marginal plot in the Brisbane Ranges, at Millers Landing road and at Lilly Pilly Gully site on Wilson's Promontory. These

sites received drainage from the unusually high Summer rainfall of 1995-6 which provided ideal warm wet conditions for the production, dispersal and subsequent root infection by the swimming spores of *P. cinnamomi*. Pathogen activity on these sites was enhanced by the unusual seasonal conditions.

The third change we observed was in the re-appearance of susceptible species on infested quadrats, from which they had previously been eliminated by *P. cinnamomi*. At previous inspections susceptible species had sometimes appeared briefly, only to become infected and die. But now these susceptible species continued to survive and grow for a period of up to 10 years. Plant species differ in susceptibility to *P. cinnamomi*. Highly susceptible species,
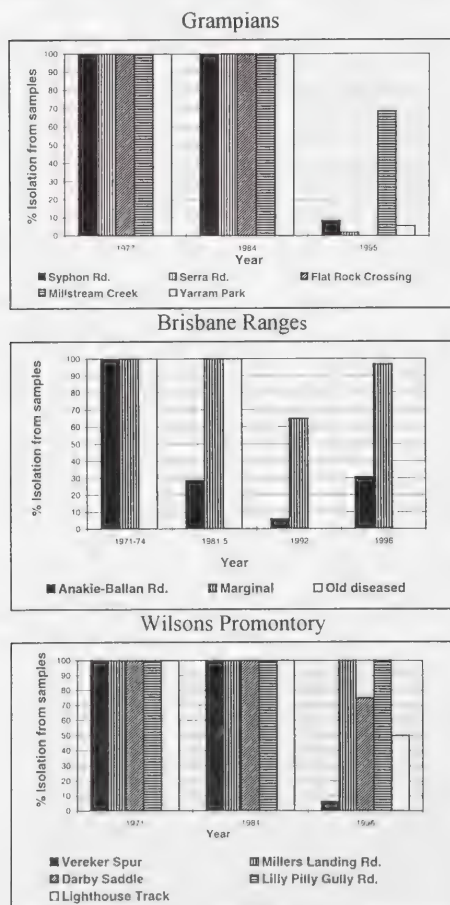
Fig. 1. Percentage isolations of *P. cinnamomi* from root samples taken from infected plants.

Fig. 2. Percentage of quadrats at n infected sites which yielded *P. cinnamomi* at different times.

Table 1. Number of susceptible species which were eliminated by *P. cinnamomi* in the 1970s but have recently regenerated and continued to survive for approximately 10 years on infected plots, as at 1995-6. Survivors are species which were not eliminated, although diseased.
Note: Regeneration refers to reappearance, usually from seed, but sometimes from underground stem or lignotuber. Survivors are less susceptible species which showed moderate to severe dieback of the branches but survived infection and have recovered by 1995-6 to produce normal growth

| Plant Family | Grampians | | Brisbane Ranges | | Wilson's Promontory | |
	Regeneration	Survival	Regeneration	Survival	Regeneration	Survival
Proteaceae	4	2	2	2	4	3
Tremandraceae	1	0	0	0	1	1
Mimosaceae	1	0	1	1	1	1
Fabaceae	5	4	5	3	4	1
Rutaceae	1	1	1	1	1	1
Thymeliaceae	1	0	0	0	0	0
Myrtaceae	2	2	0	0	2	2
Epacridaceae	6	6	3	2	3	2
Goodeniaceae	3	0	0	0	0	0
Liliaceae	1	0	1	1	1	1
Xanthorrhoeaceae	2	2	2	2	2	2
Total	27	17	15	12	20	14

such as *Xanthorrhoea australis, Isopogon ceratophyllus* and heaths disappear with infection. Less susceptible species such as *Banksia marginata* and *Grevillea steiglitziana* may survive despite chlorosis and dieback of the branches. The latter are listed as survivors in Table 1.

Regeneration of susceptible species was first observed in a large plot on the Anakie-Ballan road in the Brisbane Ranges which had probably been infected since 1962 when the road was made. Dr. Ashton and his students had noted the death and disappearance of the Grass Trees and the Prickly Cone Bush. In 1974 *P. cinnamomi* was isolated from 100% of the samples collected and tested. By 1982 only 28.6% of samples yielded *P. cinnamomi* and two young Grass Trees had appeared on the plot. By 1992 only 6% of the samples yielded *P. cinnamomi* and there were eight young Grass Trees on the plot, in addition to other susceptible species which had regenerated amongst the resistant *Hakea* spp., *Spyridium* and sedges which provided the understorey on the plot. The eight Grass Trees are still growing and many more have appeared since then (Fig. 3).

The 1995-6 study of all quadrats followed and the results have shown that regeneration and survival of susceptible species have occurred on all the plots, from which they had previously been eliminated, even in the presence of some pathogen.

On the Grampians quadrats 27 susceptible species from 11 different families have re-appeared and continued to survive. In the Brisbane Ranges 15 species from seven families have regenerated and at Wilson's Promontory 20 susceptible species from nine different families have re-appeared on infected plots (Table 1). In fact there was a general tendency for the vegetation to recover to its pre-disease structure, despite the need to compete against the resistant flora of teatree, sedges and rushes which had replaced the susceptible species. Vegetation on the infested site on Millers Landing road, Wilson's Promontory, in 1972 (Fig. 4) may be compared with that during regeneration in May 1996 (Fig. 5).

Species that have regenerated include most susceptible species, such as *X. australis*, the heaths and the peas, but there are a few absentees such as *Isopogon ceratophyllus* and *Banksia spinulosa*, perhaps due to lack of seed on the quadrats. Some of the newly regenerated Grass Trees have emerged from the base of the old dead, diseased plants and *P. cinnamomi* was isolated from the roots of both the old stump and the newly regenerated plant. The newly regenerated susceptible species were, therefore, growing in the presence of some *P. cinnamomi*.

Discussion

Dieback disease goes through three major phases.

1. The aggressive phase is characterised by dieback and death of trees, and the chlorosis (yellowing), dieback and death of

Fig. 3. Regeneration of young *Xanthorrhoea australis* at the base of an old infected plant, on the Anakie-Ballan Road in the Brisbane Ranges.

Fig. 4. Millers Landing Road, Wilson's Promontory, 1972.

shrubs. There is a disease front, often made obvious by a row of collapsed Grass Trees in the path of infection associated with the devastation of all susceptible species, and finally followed by bare ground. Depending on soil water and soil temperatures trees may die rapidly with all leaves attached, or may gradually dieback leaving bare branches to topple after three years. This phase lasts one to three years.

2. The second or colonising phase occurs when resistant species replace the original vegetation. Teatree, sedges and rushes colonise the site usually quite densely. These rather drab plants replace the colourful heaths, peas and Grevilleas. At this stage many people accept the resistant flora as the natural vegetation. Highly susceptible species which regenerate on these sites become infected and die. This stage lasts about 10 years.

3. In the third phase both pathogen and the disease it causes are declining and highly susceptible species are regenerating. This is the stage I have reported in this paper, and it has occured about 20–30 years after infection.

On the large site on the Anakie-Ballan road there has been healthy regeneration of many susceptible species and the pathogen is hard to isolate. However, recently, following the warm moist summer of 1995–6 which favoured the swimming spores, a new infection has occurred on the Eastern border. Here the pathogen is in the first or aggressive phase. There is a disease front, susceptible species are being killed, and *P. cinnamomi* is readily isolated. The three phases were observed at different parts of the same site at the same time, May 1996.

What has caused the change to phase 3? What has caused the decline in pathogen population density and distribution? Can we explain the regeneration and survival of susceptible species in the presence of *P. cinnamomi* which had previously killed them ? Here are some suggestions:

1. Perhaps a high population of swimming spores of *P. cinnamomi* is necessary for epidemic disease to occur. The release of large numbers of swimming spores probably only occurs when there is a high density of susceptible roots, free water and a temperature above 12°C. With sufficient regeneration of susceptible species, and suitable warm, moist conditions, such an

epidemic may recur.

2. A change in soil microbiology has been demonstrated with continued infection (Weste and Vithanage 1978). Microbial antagonism to *P. cinnamomi* has also been demonstrated (Stirling *et al.* 1992). Six actinomycetes antagonistic to *P.cinnamomi* have been cultured and later composted for experiments in biological control when growing susceptible species on infested soil (Guest and Aryantha *pers. comm.*). The swimming spores are particularly vulnerable to soil antagonists because they have no cell walls. Antagonistic soil micro-organisms such as actinomycetes or certain bacteria may, therefore, prevent sufficient increase in numbers of swimming spores for epidemic infection.

3. The presence of virus-like double stranded R.N.A. in some *Phytophthora* spp. has been shown to cause hypovirulence in the pathogens. Dr. Andrew Davidson, Microbiology, Monash University has screened hundreds of isolates for the presence of these particles. If detected, the isolates containing them would need to be checked for altered pathogenicity (Davidson *pers. comm.*).

Disease, death and regeneration may become cyclic phenomena, with the rate of the cycle depending on a conducive environment, the availability of susceptible host roots and a certain minimum pathogen population. The reappearance of susceptible species may initiate a second epidemic cycle.

Facilities for the control of disease due to *P. cinnamomi* have improved. Foliar sprays of phosphonates may be delivered either from the air or from backpack onto diseased vegetation. Trunk injection or soil

Fig. 5. Millers Landing road, Wilson's Promontory, 1996. *X.australis* competes with the resistant *Gahnia radula* and *Lepidosperma semiteres*.

drenches may also be used, but the soil micro-organisms convert phosphonate into phosphates which will not kill the pathogen. Phosphonate has a complex mode of action which slows pathogen activity and allows infected plants more time to invoke defence reponses. It is water soluble and non-toxic to man and animals, and is translocated in plant sap.

Eventually, and gradually a selection for resistance among susceptible species may be expected, such as has been found in Jarrah *E. marginata* (McComb *et al.* 1991).

Authorities for the nomenclature of vascular plants are according to Ross (1993).

Acknowledgements

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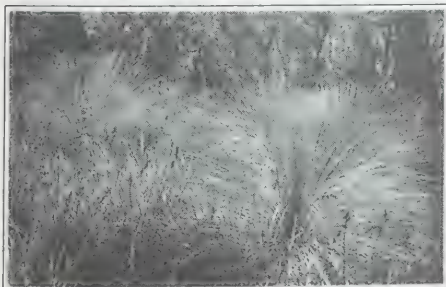
Inter-annual, Seasonal and Altitudinal Differences in Invertebrate Activity in the Snowy Mountains

K. Green[1]

Abstract
Invertebrates were trapped in pitfalls at three altitudes above the winter snowline in the Snowy Mountains. The numbers of invertebrates trapped were not adversely affected by shallow snow or drought conditions in 1982/1983. The most noticeable climatic effect was in the timing of flushes of different invertebrates, with the sequential flushes of Amphipoda and Collembola being compressed into late autumn in the high subalpine site. The alpine site was less affected by seasonal changes in precipitation as it was commonly drier, and because the earlier peaking Amphipoda were uncommon. The species composition of the collembolan fauna was quite different in different years, whereas that of the Araneae and Coleoptera was more constant. Late-falling snow after the thaw had a greater negative effect on summer abundance than did late-lying snow, and indicates the value of an existing snow cover in harsh conditions. The numbers of species caught in pitfall traps decreased with altitude, although, this was less marked in the Collembola and Araneae than in the Coleoptera. Seasonal effects were similar to those reported from sites overseas which are also subjected to seasonal snow. (*The Victorian Naturalist* 114, 1997, 222-229).

Introduction

There are few studies of the invertebrates, particularly ground dwelling invertebrates, occurring above the winter snowline in Australia. Two studies investigated invertebrates along altitudinal gradients in the Snowy Mountains; Wood (1974) studied earthworms at altitudes from 910 to 2160 m, and Dearn (1977) studied grasshoppers up to the winter snowline. Green (1983) examined life cycles of alpine grasshoppers throughout the year in the laboratory. The interaction between active insects and snow cover has largely been confined to the examination of insects found on the snow surface (Edwards 1973; Osborne *et al.* 1978). However, these insects are generally non resident species and are probably far outnumbered by the insects active beneath the snow. These have received very little attention apart from a report by Green (1982) on results of excavating pitfall traps in Kosciusko National Park from beneath the snow in the heavy snows of 1981. In addition, there are few data on winter-active invertebrates from the subnivean space (the space beneath the snow) of mountains elsewhere in the world, with most reports coming from low-lying areas of Germany (Heydermann 1956) and Manitoba (Aitchison 1974 and subsequent papers).

The aims of this study were to examine the effects of season and altitude on the composition and activity of the invertebrate ground

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fauna and to see how activity compared in drought affected and 'normal' years.

Sites and methods

The alpine zone of the Snowy Mountains of New South Wales is characterised by a continuous snow cover for at least four months per year and six to eight months with minimum temperatures below freezing (Costin 1957). The alpine zone extends from the summit of Mt Kosciusko (2228 m) to the treeline, which lies between 1800 m and 1900 m, being higher on sheltered slopes. The subalpine zone lies between the treeline at its upper limit and the winter snowline at its lower limit; this broadly correlates with the extent of *Eucalyptus pauciflora* woodland. The subalpine zone is characterised by a continuous snow cover for one to four months per year with minimum temperatures below freezing for about six months per year (Costin 1957). Data on precipitation were collected from the nearest weather station (Thredbo Village) at 1380 m located 5 km from the 1850 m and 2000 m study sites (Table 1). Shade air temperature was recorded hourly at 1850 m near the South Ramshead with a Grant, nine channel temperature recorder. Snow data were obtained from the Snowy Mountains Hydro Electric Authority's snowcourse at Spencers Creek (1830 m), approximately 15 km from the high subalpine site.

Twenty pitfall traps were set in a grid pattern covering about 1000 m[2] at each of three sites: (1) a low subalpine site (Smiggin

Table 1. Precipitation (rainfall equivalent) for Thredbo Village (1380m) during the course of the present study. *No record available.

Year	1981	1982	1983
Jan		113	66
Feb		7	68
Mar		124	204
Apr		77	240
May		*	312
Jun		40	
Jul		38	
Aug		47	
Sep		213	
Oct		57	
Nov	118	44	
Dec	138	73	

Fig. 1. View of the pipe erected to allow pitfall traps to be extracted through the snow without disturbing the snow cover. The pitfall can be seen in the gap at the bottom of the pipe.

Holes, 1680 m) with a cover of *E. pauciflora* woodland and heath, (2) a high subalpine site (South Ramshead, 1850 m) which consisted of boulder heath with overlying *E. pauciflora*, and (3) an alpine site (South Ramshead, 2000 m) consisting of boulder heath. The pitfall traps were left open and cleared monthly throughout a study period from December 1981 to May 1983 and from April to December 1986. Pitfall traps were white plastic disposable drink cups of 70 mm diameter. These contained approximately 20 ml of preservative consisting of 5 parts propylene phenoxytol, 45 parts propylene glycol and 50 parts formalin in 900 parts water (Upton and Norris 1980).

Disturbance of the soil around pitfall traps during the monthly clearance was prevented by placing a tin in the ground as a permanent receptacle for the pitfall trap. The lip of the plastic cup covered the rim of the tin, leaving no gap, and the bottom of the tin was cut to allow drainage of water and to construct two anchors to prevent the tin being pulled out of the soil. To allow access to the pitfall traps in winter a one metre polythene pipe of 91 mm diameter was erected vertically over the pitfall trap, and was capped with an inverted tin. The pipe was attached to a steel stake and held 20 mm off the ground to allow invertebrates access to the pitfall trap (Fig. 1). The pitfall trap contained a piece of dowling fixed across its diameter to allow it to be hooked and extracted through the vertical pipe. Because of the methods used only specimens $\geq$ 1 mm were counted.

Numbers in pitfall traps were compared altitudinally using Student's t-tests in 1982/83 (when two altitudes were compared) and ANOVA and Scheffe F-test

in 1986 (when three altitudes were compared).

Results
Difference between years

There was an unbroken presence of winter snow on the ground between May and October 1982 and June to November 1986 at the higher sites but at the 1680 m site snow was gone by October 1986. The summer of 1982/83 was drier than the summer of 1981/82 (Table 1). The average air temperature at the 1850 m site was higher in January 1983 (14.2°) than in 1982 (12.9°) but lower in February 1983 (12.5°) than in 1982 (13.6°). Higher numbers of invertebrates were captured in pitfall traps in both the alpine and high subalpine sites during the drier summer of 1982/83 than in 1981/82 (Fig. 2). In 1982, the numbers caught in the alpine site fell from January to April and rose to May/June before falling again. In the high subalpine site, however, the numbers caught rose to a peak in April. In 1983 the peak in invertebrate numbers occurred in January in both the alpine and high subalpine sites and declined to a low in April.
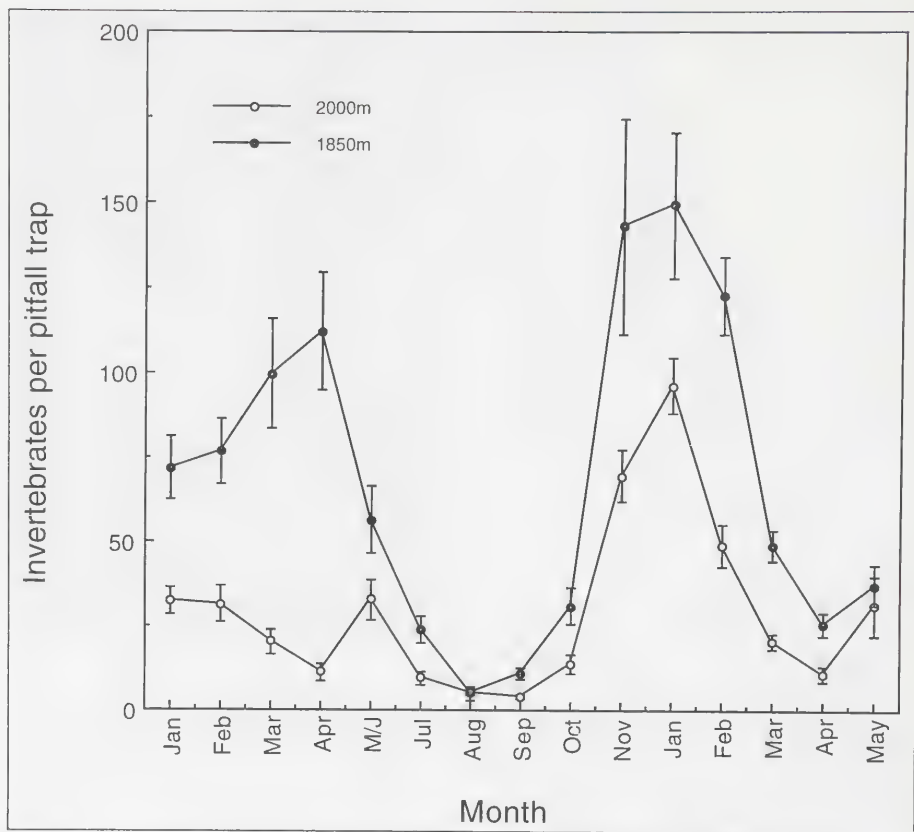
Fig. 2. The mean number of individuals per pitfall trap with standard errors in the alpine site (2000 m) and high subalpine site (1850 m) for 1982 and 1983.

Differences between seasons

There was a general decline in the numbers of invertebrates in pitfall traps from snow-free months to winter with an increase in spring (Fig. 2). The lowest numbers of invertebrates in pitfall traps in winter 1982 fell to 12.2% and 4.6% of maximal numbers from the preceding snow-free months in the alpine site and subalpine site respectively (Fig. 2) with winter numbers being similar in 1986 (Fig. 3).

In 1982, the subnivean captures were dominated numerically by the Collembola, Coleoptera and Araneae with Acarina and Diplopoda occasionally important (Table 2). No other taxon approached 10% by number of trapped invertebrates. These taxa also dominated the 1986 results but with the greater prominence of Diptera and Hymenoptera on the lower altitude trap sites.

In order of abundance in subnivean pitfall traps the families of Araneae were:

'Amaurobiidae', Linyphiidae, and Lycosidae, with three families – Micropholcommatidae, Orsolobidae and Thomisidae – equal last. There were no specialist winter species. The most common winter species, 'Rubrius' sp. and Storenosoma sp., were also the most common species in summer.

In order of abundance in pitfall traps for 1982 and 1983, generally the families of Collembola were ranked: Neanuridae, Entomobryidae, Sminthuridae, Tomoceridae, Hypogastruridae, Paronellidae and Isotomidae. In winter 1981, however, Sminthuridae were most common, and in winter 1982 Neanuridae were most common. Overall, in order of abundance in subnivean pitfall traps the Collembola were ranked: Sminthuridae, Neanuridae, Entomobryidae, Tomoceridae, Hypogastruridae and Isotomidae.

There were very few winter-active coleopteran species since only 11 species
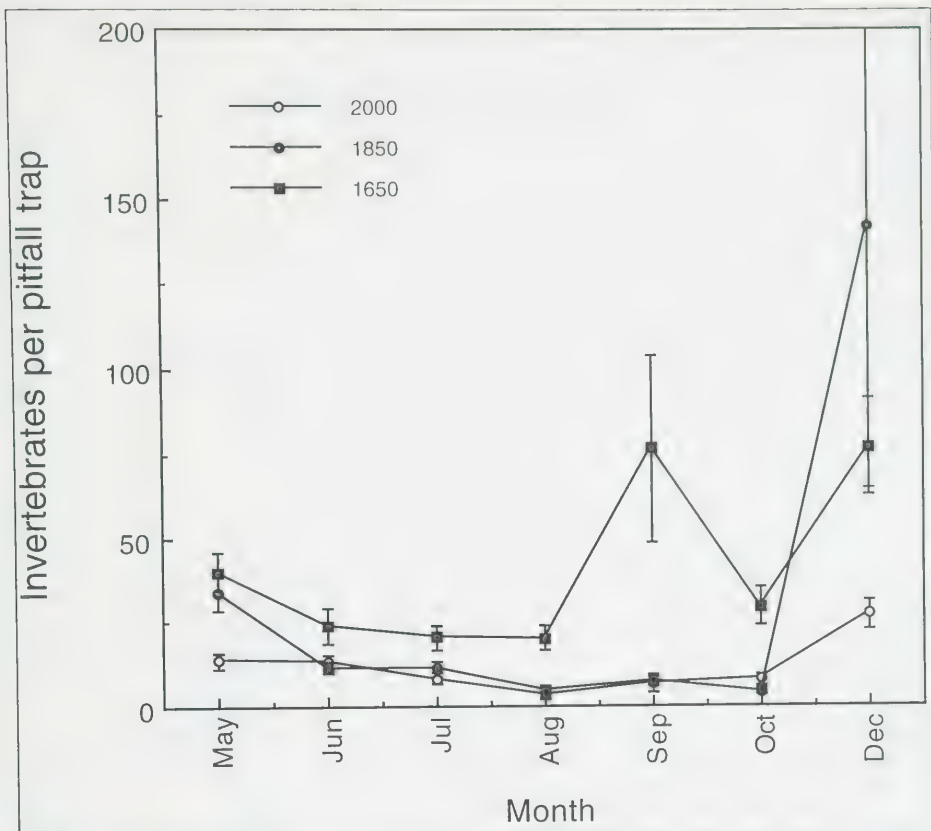
Fig. 3. The mean number of individuals per pitfall trap with standard errors in the alpine site (2000m), high subalpine site (1850m) and low subalpine site (1680m) for May to December 1986.

(i.e. 8.5% of the total trapped during the study) were trapped beneath the snow. Eight families were represented in winter pitfall traps with only the Carabidae and Curculionidae being represented by more than one genus. There were no specialist winter species, all winter-active species also being trapped in summer.

Altitudinal differences

Throughout 1982 and 1983 the alpine pitfall captures were dominated numerically by Collembola, Coleoptera, Diptera and Hymenoptera, whereas the high subalpine site was dominated by Amphipoda, Collembola, Coleoptera and Diptera. For comparable months the fauna in the alpine and high subalpine sites were similar in 1986 to those in 1982/83 except for the greater numerical importance of the Araneae in both sites and the lesser importance of the Diptera in the subalpine site (except for

December). The low subalpine site was dominated by Collembola and Araneae, which together averaged two-thirds of the fauna and never fell below one-half.

The numbers of invertebrates in pitfall traps in the high subalpine site were significantly higher than in the alpine site for the warmer months (January to April) of 1982 and 1983 (Fig. 2). In months between May and December (1982, 1983 and 1986) the differences were not so clearcut with most months not showing significant differences and only July and September 1982 and May 1986 significant at the 0.05 level. Numbers of invertebrates in pitfall traps at the low subalpine site were significantly higher than for the high subalpine site throughout 1986 (with the exception of May and December), and were significantly higher than for the alpine site in all months (Fig. 3).

Table 2. The percentage contribution by numbers to the pitfall-trapped invertebrate fauna by various groups in winter1982 and 1986. A=Alpine; SA=Subalpine; LA=Low subalpine. Total numbers of individual invertebrates collected each sampling period are included at the bottom of the table.

	1982	Jul	Aug	Sep	1986	Jul	Aug	Sep/Oct
Oligochaeta	A	1.3	0.0	0.0		1.0	0.0	1.3
	SA	0.3	0.0	0.0		0.0	0.0	0.0
	LA	-	-	-		0.3	0.0	0.2
Gastropoda	A	0.0	0.0	0.0		1.0	0.0	3.8
	SA	0.0	0.0	0.0		0.0	3.3	3.8
	LA	-	-	-		0.0	0.0	0.0
Isopoda	A	1.3	0.0	0.0		0.0	0.0	0.0
	SA	0.3	0.0	0.0		0.0	0.0	0.0
	LA	-	-	-		0.0	0.4	0.0
Amphipoda	A	0.0	0.0	0.0		0.0	0.0	0.0
	SA	2.4	0.0	0.8		3.7	3.3	2.5
	LA	-	-	-		0.3	0.4	0.1
Diplopoda	A	5.3	26.7	0.0		7.8	16.7	3.8
	SA	1.3	4.9	0.8		1.9	3.3	5.1
	LA	-	-	-		0.3	0.4	0.1
Chilopoda	A	1.3	0.0	0.0		0.0	0.0	0.0
	SA	0.5	1.2	0.0		0.0	0.0	1.3
	LA	-	-	-		0.0	0.0	0.0
Symphyla	A	0.0	0.0	7.1		1.0	0.0	0.0
	SA	0.0	0.0	0.0		0.6	0.0	2.5
	LA	-	-	-		0.0	0.4	0.0
Pseudoscorpiones	A	1.3	0.0	0.0		0.0	0.0	0.0
	SA	2.1	1.2	0.0		0.0	0.0	0.0
	LA	-	-	-		0.9	0.4	0.0
Acarina	A	8.0	16.7	3.6		0.0	8.3	6.3
	SA	1.9	1.2	7.5		1.2	6.7	2.5
	LA	-	-	-		3.4	4.6	1.1
Araneae	A	4.0	3.3	39.3		35.0	4.2	3.8
	SA	5.9	14.8	15.8		41.4	20.0	12.7
	LA	-	-	-		9.0	3.5	1.8
Opiliones	A	0.0	0.0	0.0		0.0	0.0	0.0
	SA	0.3	1.2	0.8		0.0	0.0	0.0
	LA	-	-	-		0.6	0.0	0.1
Collembola	A	64.0	40.0	39.3		15.5	45.8	27.8
	SA	70.4	50.6	35.8		25.3	16.7	26.6
	LA	-	-	-		61.1	71.6	80.1
Coleoptera	A	1.3	10.0	3.6		12.6	0.0	8.9
	SA	4.0	16.0	25.8		13.0	23.3	29.1
	LA	-	-	-		4.0	0.4	1.3
Lepidoptera	A	0.0	0.0	0.0		3.9	0.0	0.0
	SA	0.0	0.0	0.0		1.2	0.0	0.0
	LA	-	-	-		0.0	0.0	0.0
Diptera	A	5.3	0.0	0.0		12.6	8.3	2.5
	SA	0.3	2.5	1.7		6.2	10.0	5.1
	LA	-	-	-		3.7	5.3	9.6
Hymenoptera	A	0.0	3.3	3.6		0.0	8.3	10.1
	SA	1.3	0.0	2.5		3.1	0.0	0.0
	LA	-	-	-		3.7	3.9	2.1
Blattodea	A	0.0	0.0	3.6		0.0	0.0	0.0
	SA	0.3	0.0	1.7		0.6	0.0	0.0
	LA	-	-	-		0.3	0.0	0.1
Hemiptera	A	1.3	0.0	0.0		3.9	4.2	0.0
	SA	0.8	0.0	0.0		1.9	3.3	0.0
	LA	-	-	-		0.0	0.0	0.0
Thysanoptera	A	0.0	0.0	0.0		0.0	0.0	0.0
	SA	0.0	0.0	0.0		0.0	0.0	0.0
	LA	-	-	-		0.3	0.0	0.0
Larvae	A	5.3	0.0	0.0		5.8	4.2	31.6
	SA	8.0	6.2	6.7		0.0	10.0	8.9
	LA	-	-	-		12.0	8.9	3.5
Total 2000 m		75	30	28		103	24	79
Total 1850 m		375	81	120		162	30	79
Total 1680 m		-	-	-		324	282	1068

Discussion
Difference between years

Higher numbers of invertebrates were captured in the drier summer of 1982/83 than in the wetter 1981/82. This is in contrast to the findings of Woinarski and Cullen (1984) who found a decline in numbers of invertebrates from arboreal foliage in Victorian forests over a similar period (June 1981 to April 1983). Although droughts usually correspond with warmer weather and therefore higher metabolic activity, higher temperatures were apparently not the cause of the increased activity by ground dwelling invertebrates in the present study. Temperatures in summer 1982/83 were both higher (January) and lower (February) than in summer of 1981/82. The high number of invertebrates in summer in each year was made up of a general increase in most invertebrate types but also a large influx of flies which may have been attracted to the traps.

There was a rise in the numbers of invertebrates caught in all sites (except in the subalpine site in 1982) from April to May. Maximal numbers in pitfall traps have been found in autumn in New Zealand (Moeed and Meads 1985). The summer peak and the April/May peak were caused by flushes of different types of invertebrates. The summer flush was of most invertebrate types. Once the weather became wetter and cooler there was also a secondary flush of Amphipoda and Collembola. In the dry summer of 1982/1983 there was a clear separation of these flushes with numbers of invertebrates peaking in the first flush in December/January but then rapidly falling and not rising again until April/May when Amphipoda and Collembola peaked together. This situation was similar in the alpine site in both years. Because the alpine site was drier than the subalpine site it tended to vary less between years and both years showed the 'dry year peak'. In the subalpine site in 1982 this flush consisted first of Amphipoda in March and then of Collembola in April. This led to a gradual decline in invertebrate numbers rather than a fall and rise as occurred in drier conditions in 1983.

Differences between seasons

Aitchison (1984), working in a seasonally snow-covered site in Manitoba, found that the numbers of invertebrates in pitfall traps, and the diversity of species generally, decreased in autumn, were lowest in winter and increased gradually in late spring. The present study differed with respect to autumnal peaks and the rapid increase in spring in both sites in 1982 (Fig. 2), and in the high subalpine site in 1986, although it was more gradual in other sites in 1986 (Fig. 3).

The low numbers caught in December 1986 at the low subalpine site were a result of the decline in numbers in October, which was caused by a heavy October snowfall occurring after the thaw. Invertebrates had already emerged from diapause at that altitude, and many were trapped and killed by this fall of about 30 cm of snow. Numbers were not negatively affected at 1850 m and 2000 m because, as the snow cover had not thawed, the invertebrates had not emerged.

In Manitoba Diptera and Hymenoptera were active early and late in the winter (Aitchison 1979a). In the present study Diptera and Hymenoptera occurred throughout the winter with both winged and apterous species being caught. Molluscs, oligochaetes, centipedes and pseudoscorpions were caught infrequently under snow in Sweden (Nasmark 1964) and in Canada (Aitchison 1979b, 1979c). The same was true in the present study, although, pseudoscorpions were more likely to be caught in the subnivean space than in snow-free months. The numbers of millipedes was variable and in one month (August 1982) constituted over a quarter of the subnivean fauna in the alpine site, which is a higher proportion than that reported from elsewhere.

The major subnivean families of Araneae in aspen parkland in Manitoba were Clubionidae, Erigonidae and Lycosidae, with lower numbers of Linyphiidae, Tetragnathidae, Agelenidae, Hahniidae and Thomisidae (Aitchison 1978). The first five families were also found beneath the snow at various sites in Europe (Aitchison 1978). Although Europe and Canada share a similar subnivean range of families of Araneae, the fauna in the Snowy Mountains is quite different, sharing only two families (Lycosidae and Linyphiidae), with Europe; these and a third (Thomisidae), are also shared with Canada. Additionally, the major subnivean family in the Snowy Mountains, both in summer

and winter, was the 'Amaurobiidae', which is not represented at all in the subnivean fauna of Europe or Canada.

Collembola are, in general, characteristic of arctic and high alpine environments (Agrell 1941; Fjellberg 1975; Chernov 1985) and, numerically, are the most commonly trapped subnivean invertebrates in Sweden (Nasmark 1964) and the second most common in Canadian aspen parkland after the Acari (Aitchison 1979d, e). In the present study, Collembola were the most commonly trapped subnivean invertebrates in the alpine and subalpine sites in 1982; in 1986 they were the most common in the low subalpine site, but in the high subalpine and alpine sites, Araneae were more common early in the winter, and Collembola were more common in the second half of the winter.

The Isotomidae and Entomobryidae were the two most commonly trapped families in the subnivean space both in Europe and in Canadian aspen parkland (Nasmark 1964; Aitchison 1979d), and the Isotomidae also appears to be the most common family living on the snow surface in the Swiss Alps (Block and Zettel 1980). In the present study, these two families were poorly represented in the subnivean fauna (ranked 6th and 3rd respectively out of six families of Collembola); the Sminthuridae and Neanuridae being the two most commonly trapped families. Aitchison (1979d) winter-trapped 16 species (mainly consisting of isotomids) in Canada which is similar in number to the 19 species trapped here.

In Manitoba, Aitchison (1979f) found 62 species of Coleoptera, from five families, active in winter beneath the snow. In order of abundance in pitfall traps these were Staphylinidae, Carabidae, Lathridiidae, Cantharidae and Erotylidae. Staphylinidae were also the most commonly caught of the subnivean Coleoptera near Kiele in Germany (Heydemann 1956). In the Snowy Mountains, the order of abundance of individuals was Leiodidae, Carabidae, Melandryidae, Curculionidae, and Lathridiidae, with Scymaenidae and Endomychidae being ranked equal last. The Staphylinidae were well represented in the Snowy Mountains in the pitfall-trapped fauna (18 species) but only in months without snow cover, as was the Cantharidae.

The subnivean Coleoptera of the Snowy Mountains are therefore distinct from those of both Manitoba and Germany.

There are few comparative data on winter-active invertebrates from the subnivean space of mountains elsewhere in the world but, in terms of subnivean activity *per se*, the families of Araneae, Collembola and Coleoptera differ from those in the northern hemisphere. This could, in part, be due to the isolation of the Snowy Mountains from snow-covered mountains elsewhere, and/or because the taxa from which the mountain forms evolved differed from the assemblage of taxa represented elsewhere. The invertebrate fauna of the Snowy Mountains, therefore, present an ideal assemblage of animals for studies of mountain biogeography and evolution.

Altitudinal differences

The numbers of invertebrates generally decrease with increasing altitude (Mani 1968). In the present study, numbers caught at the low subalpine site were significantly higher than for either the alpine site or (in most months) the high subalpine site and, except in winter, the numbers of invertebrates caught on the high subalpine site were generally higher than for the alpine site. Fewer invertebrates were caught on the high subalpine site at all times of the year than in tall open forest at 800 m (Dickman *et al.* 1983). Such comparisons might be misleading because of differences in the vegetation type, the dryness of the habitat, or other factors that might not be altitude-dependent. However, the aspect, shrub strata, soils and rock were similar at both the alpine and high subalpine sites, and the lack of trees at 2000 m is an effect of altitude and not an artefact of site selection. Therefore, the differences between these two sites can ultimately be attributed to altitude.

In the present study, the decline in species richness with increasing altitude was small in the Collembola and Araneae, but was quite evident in the Coleoptera with 100 species in the subalpine site compared with 68 in the alpine site. The decline in faunal richness with altitude could be due to one or more of several factors: (a) a reduction in suitable habitat or resources with altitude (Connor and McCoy 1979; Hebert 1980), (b) harsher and more variable environments

at higher altitudes (Sanders 1968; MacArthur 1975; Hebert 1980), (c) reduced primary productivity (Connell and Orias 1964), or (d) the lack of time for a special fauna to evolve. The diversity of the Araneae and Collembola were unaffected by the change from tree cover to a treeless alpine environment. In the case of the Araneae this may, in part, be explained by the possibility of individuals ballooning up on rising winds. No arboreal species of Araneae were lost in the transition from subalpine to alpine and, in fact the normally arboreal *Diaea* (Stiphiidae), were found only in the alpine site.

Conclusion

The ground-dwelling invertebrate fauna of the Snowy Mountains presents a rich field of study for students of mountain biology and biogeography, with marked differences according to altitude, season and year and a subnivean faunal assemblage that differs from that studied overseas. The response of the subnivean invertebrate fauna to these differences presents an opportunity to study the long-term impact of climate change, particularly in regard to the effects of differing snow cover.

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Introduction of the Sugar Glider *Petaurus breviceps* into Re-established Forest of the Organ Pipes National Park, Victoria

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Abstract
In 1989. 13 Sugar Gliders *Petaurus breviceps* were introduced into the Organ Pipes National Park, a re-afforested valley, 26 km north-west of Melbourne, Victoria. These Sugar Gliders were relocated from a nearby (20 km) State Forest at Pyrete Range. Toolern Vale. This initial release was followed up in 1990 with the release of a further 24 animals. Due to the absence of natural tree hollows, 24 nesting boxes were installed prior to the release. spread over a 10 ha area. Introduced glider population densities varied from 0.8 ha^{-1} to 5 ha^{-1} from February 1989 to October 1992. In June 1993. 43 Sugar Gliders were trapped and nesting boxes were installed over a wider area. By May 1995, 31 Sugar Gliders were trapped, marked with 'electronic chips' and some were found nesting in boxes specifically designed for bats. Although there had been a number of reintroduction's at other locations in Victoria, namely Tower Hill, Blackburn Lake and Coolart, this was the first time wild Sugar Gliders had been trapped and relocated. Due to senescence amongst Black Wattles *Acacia mearnsii* at Organ Pipes National Park, food sources may have reduced during the study period. Despite this, the data indicate that the population may have been successfully established.
(*The Victorian Naturalist* **114**, 1997, 230-239).

Introduction

This study documents the introduction of wild Sugar Gliders into Organ Pipes National Park (OPNP) from 1989 to 1995 and makes comparisons with other Sugar Glider release programs in Victoria. It was conducted to estimate the survival of those released *Petaurus breviceps* into Organ Pipes National Park, and uses available data kept during this period. Recommendations are made for future management of this Sugar Glider population at Organ Pipes National Park and other release programs in Victoria.

The study area

The Organ Pipes National Park (OPNP) (37° 40' S, 144° 45' E) (Figs 1-3) was declared in 1972 and it currently has a total area of 121 ha. A continuing rabbit problem has meant that, until very recently, almost no young trees have naturally regenerated and there is almost no understorey. As a result, the area has many well-grown trees of nearly the same age (Kemp and Irvine 1993. Nevertheless, a preliminary evaluation of the alluvial flats concluded that the habitat had become adequate for a fauna release program and could support a small population of Sugar Gliders (FOOP Nov 1987, Feb 1988). The release area was set as the alluvial flat in the bend of Jackson's Creek opposite the

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Organ Pipes formation. This is divided in two by a steep ridge along which the main track into the valley has been constructed. There are about 5 ha of alluvial flat either side of the central ridge.

Climate

Climatic records for OPNP have been maintained since 1972 and show the area
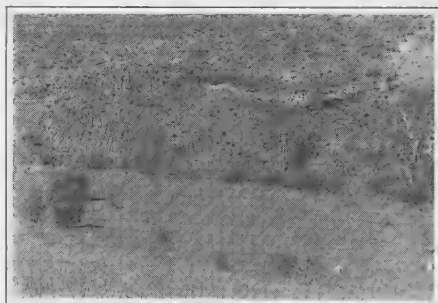
Fig. 1. River Flat, Organ Pipes National Park, September 1978. Photo: D. Marsh.

Fig. 2. Organ Pipes National Park, October 1990.

Fig. 3. Organ Pipes National Park, Victoria showing the location of artificial hollows in 1992.

to be a rain shadow, with a mean annual rainfall of 575 mm. This is considerably drier than Tower Hill (730 mm) and Willung (750 mm), where wild Sugar Glider populations were studied by Suckling (1983), and both sites were at more southerly latitudes than OPNP. Mean temperatures are similar (20°C at OPNP and 18°C at Tower Hill in February), with a mean of 10°C at both places in July. In late spring and summer, evaporation exceeds rainfall (Willis 1964) and moderate frosts occur during winter. A full account of the climate is given by McDougall (1987) and Wilk *et al.* (1978).

Vegetation

The study area in OPNP had been largely denuded of vegetation by 1972 and the land was very degraded, with 90% covered by 24 species of noxious weeds, dominated by African Boxthorn *Lycium ferocissimum*, Spanish Artichoke *Cynara cardunculus* and Horehound *Marrubium vulgare*. It was infested by rabbits, foxes and other vermin, and became severely eroded (Edwards 1974). Few native plants or animals survived except where some protection was provided by rock crevices or creek banks.

By 1989 the revegetation project at OPNP had been an outstanding success as indicated by the diversity of indigenous species found in the Park. Woodlands of trees and shrubs now provide excellent habitat for native animals. Natural regeneration of trees and shrubs is now occurring where the rabbit population has been controlled (Kemp and Irvine 1993). It has been planted with a forest of River Red Gum *Eucalyptus camaldulensis* and Manna Gum *Eucalyptus viminalis*, Blackwood *Acacia melanoxylon*, Silver Wattle *A. dealbata*, Black Wattle *A. mearnsii* with dense growth of Woolly Tea Tree *Leptospermum lanigerum* and River Bottle-brush *Callistemon sieberi* at the water's edge.

The area known locally as Middle Flat (Fig. 3) is part of the Red Gum zone of the original planting plan (Kemp and Irvine 1993). By 1989, there were Yellow Box *Eucalyptus melliodora*, Yellow Gum *Eucalyptus leucoxylon*, River Red Gum and Manna Gum which have grown to a height of 20 m. There was also a mixture of Wattles, including Black Wattle, Silver Wattle, Wirilda *A. retinodes* and Golden Wattle *A. pycnantha* which had reached 10 m in height. The principal understorey plants are grasses, Tree Violet *Hymenanthera dentata*, River Bottlebrush, Sweet Bursaria *Bursaria spinosa*, Lightwood *Acacia implexa* and Silver Banksia *Banksia marginata*.

Fauna

A general fauna survey conducted in February 1988 by Arthur Rylah Institute (Department of Conservation and Natural Resources – DCNR, now DNRE) recorded no Sugar Gliders (Brereton and Schulz 1988). It was accepted that the Sugar Gliders were unlikely to recolonise the park, as the nearest forest population was too far away and there was no suitable habitat in between through which they could migrate to the park. Bird surveys showed a steady increase in species using the area, and a fauna survey in 1988 showed the presence of some possum species using the creekside trees for food and nesting.

Artificial hollows

In 1972 there were few old trees with nesting hollows in the park, but a vigorous planting program since then has filled the alluvial flats with young trees. By 1989 all were still under 20 years old, so none had natural nesting hollows. Because young regenerating forest is usually an unsuitable habitat for arboreal mammals, particularly forest-dependent species (Suckling and Macfarlane 1983), the release proposal involved building artificial nesting hollows, constructed by Friends Of Organ Pipes (FOOP), to be attached to trees along the creek (Fig. 4) to make the area more habitable by Sugar Gliders.

In January 1989 two types of artificial hollows were constructed: box and log. Each hollow had a circular side entrance near the top, and a hinged lid that could be opened for inspection and cleaning out of unwanted materials such as bird nests, rats or bees. Later, in an unrelated project in the same area to provide roosting sites for bats, 10 bat roosting boxes (Fig. 4) were installed. These had smaller internal dimensions than the glider boxes, and each had a 30 mm entrance slit in the base rather than a circular side entrance. In November 1990, 20 months after the initial glider release, FOOP constructed and installed an additional 21 boxes designed for birds (but similar in design to the glider boxes), and these were installed further west in the park, upstream of the Tessellated Pavement and along Column Gully (Fig. 3).

Inspection of these in 1991 revealed that released Sugar Gliders had extended their range and were also using the additional boxes (FOOP April 1991). To further encourage the northern expansion of the Sugar Gliders range, another ten boxes (nos 60–70) were installed along Jackson's Creek in 'Burns paddock' in 1992.

Sugar Glider release program

In January 1989, young non-breeding animals were captured in the Pyrete Range, Toolern Vale, (37° 35' S, 144° 32' E) (Fig. 3). This area was chosen as suitable because the Sugar Glider population was large enough to have extra animals removed. Traps were attached to Eucalypt and Wattle trees at heights ranging from 2–5 m above the ground. A mixture of honey and oats was used as bait and, as an additional attractant, a trail of dilute honey was laid from a trap to the main stem of the tree. Initially Sugar Gliders, were selected by age (a range of 2+ years to 4 months) (Table 1) and breeding condition. They were transferred to enclosures in two compounds at Arthur Rylah Institute (ARI) for 10 days to familiarise them with their new nest boxes, to allow group interrelationships to be formed and to ensure the animals were healthy. All animals were weighed, sexed and had metal ear tags attached, male Sugar Gliders on the right ear, females on the left ear. They were transported in their nest boxes to OPNP where 'family' groups of *P breviceps* were placed in three of the 24 boxes that were attached to trees along the creek.

The first Sugar Gliders were released at

Red Gum Flat and the northern end of Main Flat in February 1989 (FOOP Feb 1989). For the first few weeks, supplementary food (baby food, egg and honey) was set out atop the glider nesting boxes. Most of this food was consumed overnight. Artificial feeding was discontinued ten days after release to encourage the young *P. breviceps* to establish their own feeding patterns.

Another trapping was conducted at Toolern Vale in February 1990 and after a week at the ARI to settle down, the Sugar Gliders were released into the park on 9 March 1990 (FOOP April 1990).

Methods
Nest box inspections
All artificial hollows (nest boxes) were inspected in daylight on a monthly basis from 1989 to 1992, and intermittently after that period. Inspection was by raising the hinged lid and looking inside the interior. Any gliders found inside were not removed from the boxes, but the number of occupants was estimated. Presence of a spherical nest of Eucalypt leaves was seen as an indicator of box use by gliders (Triggs 1989).

Spotlighting
Spotlighting sessions were conducted, by park staff and the Friends group, at about one month intervals to gauge activity of gliders throughout the park. A hand-held, 100-watt lamp was used, and the movements and number of gliders seen were recorded for each session.

Trapping
A three-day trapping program was conducted every two years, in winter, 1989,
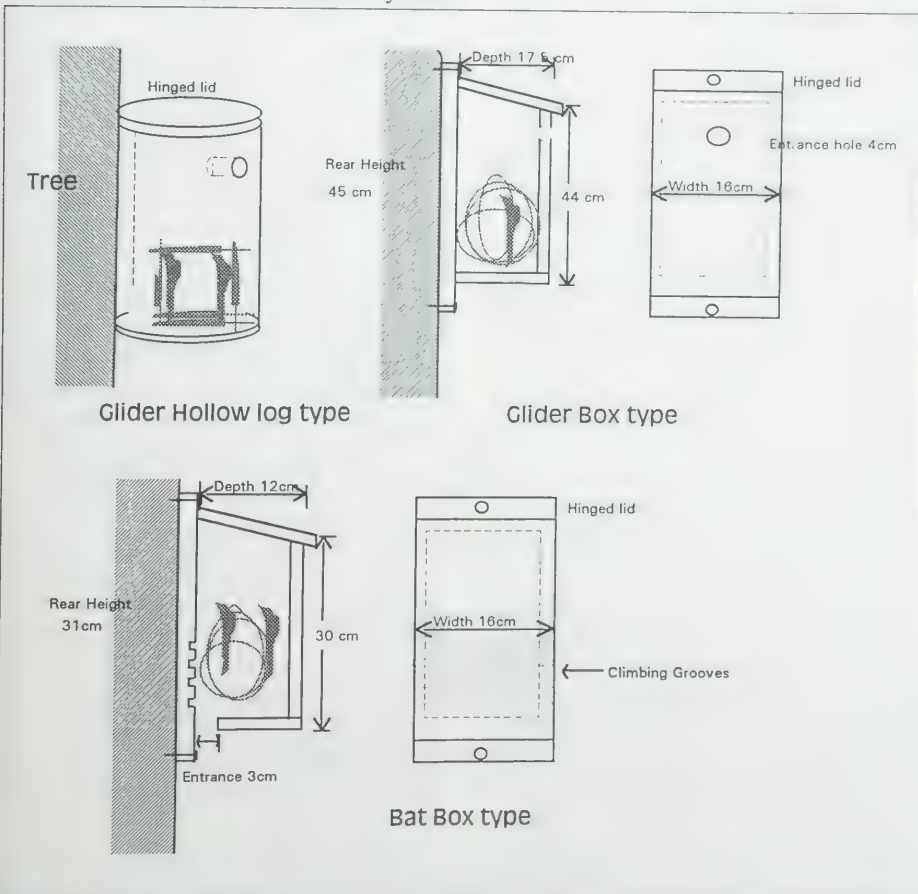
Fig. 4. Diagram of three different types of artificial hollows established at Organ Pipes National Park.

Table 1. First and second release of Sugar Gliders into OPNP.

	Sex	Estimate of age (years)	Weight (grams)
1	F	<1	78
2	F	<1	72
3	F	1+	97
4	F	1+	93
5	F	1 to 2	102
6	F	1 to 2	112
7	M	4 months	89
8	M	<1	90
9	M	<1	88
10	M	1	86
11	M	1 +	93
12	M	1 to 2	113
13	M	2 +	93
1	F	2	132
2	F	<2	115
3	F	2	137
4	M	1	88
5	M	1	74
6	M	2 +	142

Table 2. Mean weights of Sugar gliders captured at OPNP 1989– 1995 compared to Tower Hill, Pyrete Range and Willung (Suckling 83). Key: A, OPNP body weight (g); B, Pyrete Range body weight (g); C, Willung body weight (g); D, Tower Hill body weight (g).

Sex	Age (y)	A	B	C	D
Male	<1	92	89	<115	127
	1-2	97	95	100-150	140
	>2	125	117	120-160	154
Female	<1	89	78	<100	111
	1-2	120	107	90-130	121
	>2	130	128	100-140	137

1991, 1993 and 1995. Nine months after the initial release an assessment trapping was made at OPNP during Nov 15-17 1989 to determine the status of the population of wild-caught Sugar Gliders released in February. A total of 68 Elliot traps, 30x10x10 cm (Elliott Scientific Co., Upwey, Melbourne) and 8 wire traps was set over 3 nights, giving a total of 228 trap-nights. (Table 2). In June 1993, 150 aluminium Elliott traps were set up in a variety of *Eucalyptus* and *Acacia* trees along the creek. Over two weeks they were baited with a sweet food, and inspected twice a day for captured gliders. Those captured were taken to the park's Visitor Centre for data collection, including weight, sex, fur colour, condition, age (assessed by tooth wear), and ear tattoo (FOOP July 1993).

In the May 1995 trapping, 200 Elliott traps were set, covered with plastic in case of rain, and baited with a mixture of rolled oats, honey and dried apple. Socks were placed in the traps, to keep any trapped gliders warm. By this time many of the gliders had been micro-chipped and could be identified merely by passing an electronic wand over the chipped area.

Results
Number of Sugar Gliders
In February 1989 thirteen Sugar Gliders, seven male and six female (Table 1), were

released and a monitoring program was commenced immediately. By August 1989, daytime box inspections and follow-up night-time spotlighting monitoring of those boxes known to have gliders in them regularly yielded no more than two sightings (FOOP July 1989, Sept 1989).

The November 1989 trapping yielded six animals, two of which were pregnant females. Four had metal ear tags, but two were untagged, which suggested that predation by Owls (Geoff Pitt *pers. comm.*) and other predators was being offset by at least some of the gliders breeding. Sugar Gliders have a number of native predators (Brunner *et al.* 1975; Henry *et al.* 1984) that were known to be present in the park ,as well as possible introduced predators. It was therefore expected that predation by owls would mean further releases of captive gliders were needed to maintain the breeding population until a balance was achieved. On one spotlighting evening, an owl was seen swooping down to pounce on a glider and carry it off (FOOP Feb 1990). DCNR Wildlife Division was satisfied that a sufficient number of animals had survived and agreed to relocate more animals.

In 1990, another 18 gliders were trapped and subsequently released into the park in April 1990. As with the earlier releases, they were provided with an artificial food supply, daily at first and then every second day, until the frequency was reduced to fortnightly and eventually discontinued (FOOP July 1990). At this stage, a total of 37 Sugar Gliders had been released into the National Park.

The box inspection records and the May 1991 trapping suggest that the colony had split into three separate family groupings.
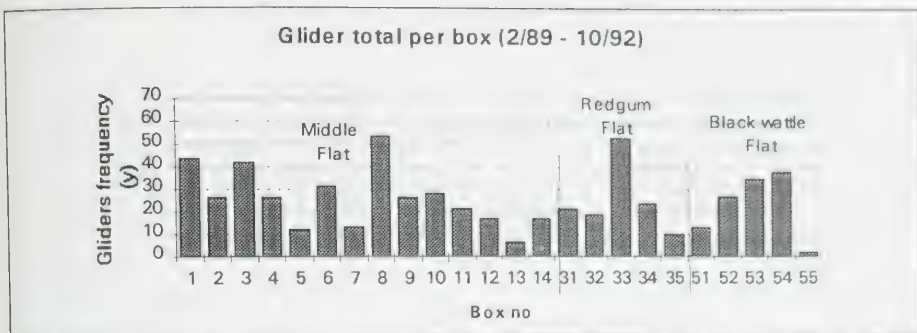
Fig. 5. Sugar Glider usage of artificial nest hollows at Organ Pipes National Park February 1989 to October 1992 (y) indicates the number of times gliders were seen in the box during the 46 monthly inspections

Three males, an older one and two younger ones, had at first formed a single colony (on Main Flat), but later the two younger males had moved off to form their own groups, one upstream in the bird boxes on Rubble Flat, the other further downstream on Black Wattle Flat. Twenty untagged animals were captured (FOOP April 1991).

In June 1993 a trapping yielded 43 Sugar Gliders, so the population had considerably increased from the group released two years earlier (FOOP Sept 1993). During this survey period, the cumulative total of successful trappings was 966 animals, many being trapped repeatedly. All the artificial hollows were occupied at some time by gliders, in addition to some boxes which contained Eucalyptus leaves woven into a ball about 25 cm in diameter, a common sign of nest-hollow use by gliders (Triggs 1989). This is consistent with the fact that a number of gliders use a several different hollows, particularly during the breeding season (Golding 1979; Suckling 1980, 1984).

In May 1995, thirty-one animals were trapped over four nights, including six which were previously unrecorded young.

Glider density

Data for glider occupation were measured using the area enclosed by boxes 1–55 for the period 2/89 to 10/92. Accurate changes in the density of Sugar Gliders can be calculated where 0 represents the density before the first release (Shulz *et al.* 1989). During the program at known times and locations certain recorded numbers of gliders were released. From then on, densities could be calculated using a combination of box inspection results and trapping results over known areas of boxes (10 ha) and

traps (Fig. 5). By July 1991 CF and L (now DNRE) reported that the glider population was increasing faster than expected and seemed to be a success (FOOP Sept 1991). Data were recorded by the use of the 'know to be alive' technique, i.e.using individual records of animals over a long time period, and if missing or not observed during one or two sessions but recorded in a later session, they were regarded as known to be alive throughout the period (Fig. 6).

Health and condition of animals

All of the original Sugar Gliders trapped at Pyrete Range were in good health, the individual weights are shown in Table 1. Comparison of later trappings at Organ Pipes National Park are shown in Table 2. The animals at OPNP had, on average, lower weights than animals at Wilung and Tower Hill. (Suckling 1983).

Discussion

The results of this release program are comparable to the similar program at Tower Hill (Suckling *et al.* 1983, 1989). The apparent lack of success at Blackburn Lake (Juzva and Peeters 1992) and of the early attempts at Tower Hill make the success of the release program at the Organ Pipes National Park very significant. Although the OPNP is, in the main, an artificially regenerated forest surrounded by cleared farmland, it does have something of a flora corridor along Jackson's creek. Assessing the survival success of the colony and the number of gliders in the area is difficult as all traps have been set within the National Park and some Sugar Gliders may have moved in and out of the

park study area in search of further food sources or nesting hollows, while some may have been forced out of the area by competing family groups. The Blackburn Lake project (Juzva *et al.* 1992) may have failed due to predation of gliders by foxes, feral cats and other introduced predators, common in urban areas. To avoid repetition of this experience, regular carnivore baiting and trapping was carried out at OPNP during the study period. It was agreed that a control program of known glider predators, foxes *Vulpes vulpes*, and cats *Felis cattus* (Brunner *et al.* 1991), had to be intensified preparatory to the proposed release, which might otherwise just be providing free food for the feral carnivores (FOOP July 1988).

By June 1991 results suggested that the glider reproduction rate was adequate to maintain the population against owl predation (FOOP June 1991). Seasonal variations in numbers of Sugar Gliders in boxes is known to be partly due to dispersal of sub-adults from parental groups, and to the formation of larger aggregations during winter perhaps to huddle together to keep warm (Menkhorst 1984).

As all those gliders released into the park had metal ear tags (Salt Lake Stamp Co., U.S.A) or had been tattooed (later micro chipped), it was possible to determine the numbers of wild-bred animals in the population. However, measurement of survival rate has problems as it is possible for gliders to move out of the park along the Jacksons Creek corridor where there are sufficient mature trees existing to provide tree hollows. So more may survive than are shown by trapping results within the park.

In April 1992, FOOP established a set of bat roosting boxes in the same general area as the glider boxes, but on different trees (Irvine and Bender 1995). The boxes had a very different design, but inspection of the bat boxes showed that several were regularly used by gliders. This was clear from the discovery that either gliders were in residence when the boxes were inspected (all ten boxes have been used by gliders at some stage), or there were leaf-nests inside the bat roost boxes, and the borders of the entrance slits on some boxes showed signs of gnawing, presumably by gliders attempting to widen the narrow entrances

to make entry and exit easier (FOOP Aug 1994, Dec 1994, Feb 1995, April 1995).

Feral honeybees in the artificial hollows

Soon after installation of the artificial tree hollows, bees established nests in two boxes, while others were regularly used by Common Brushtail Possums *Trichosurus vulpecula*, Ringtail possums *Pseudocheirus peregrinus* and Black Rats *Rattus rattus* (FOOP May 1989).

During the study, many boxes needed maintenance in the form of repair or replacement following infestation of bees, which was a problem each swarming season. Eventually a solution was found to keep bees out, which involved fitting a small pest strip under the lid of all hollows. Bees still occupied these hollows but inspections revealed heaps of dead bees which are easily removed. In comparison to the problem at Tower Hill at which bees were found in 51% of hollows (Suckling and Goldstraw 1989) OPNP was less affected. As bees were generally removed promptly, it should not have had a significant effect on the number of hollows available for use by gliders. However, at swarming season, some hollows have been occupied by aggressive bee swarms which may have caused some glider mortality due to gliders being driven out of their boxes and exposed to attack by predators (Laila Sadler *pers. comm.*).

Population size and density

Box inspections at OPNP found a maximum of four gliders per box (cf. Suckling 1984 who found a 'normal' group size of seven). This suggests that box counts could have under-estimated the number of gliders in each box. During OPNP box inspections gliders were not actually removed from boxes, but an estimate of the number of occupants was made visually. As gliders often sleep stacked one on top of another, it can be difficult to estimate accurately the number of animals in a crowded box. However, if this was the case it could be argued the Sugar Glider population is actually an underestimate and any inaccuracy should be corrected during the trapping program every two years.

It is clear from the box inspection results that all boxes were used, but that there was one box in each area that was used most
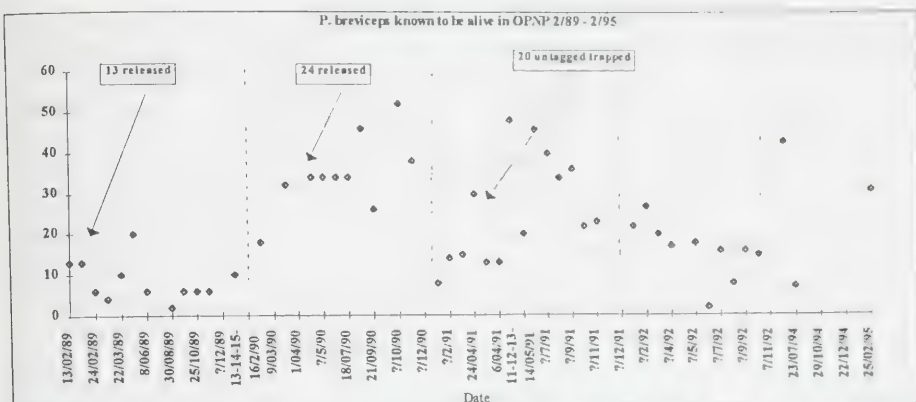
Fig. 6. Number of Sugar Gliders known to be alive at Organ Pipes National Park. Data from a combination of nest box inspections and trapping (labelled).

frequently, i.e. Box 8 in Middle Flat, Box 33 in Redgum Flat and Box 54 in Black Wattle Flat (Fig. 5). This may indicate a separate family group on each Flat.

The glider population at the park seems to have decreased after the initial release, possibly as a result of predation by owls, but after the 1990 releases appears to have increased significantly over the following three years, with a maximum park population of around 43, reached in 1993. Since then, there has been some decline, to around 30. This may be the result of multiple causes, with some animals moving along the creek beyond the park boundaries and so beyond the reach of the trapping program. It may indicate something about the carrying capacity of this area, with dispersing young having to seek territories outside the National Park. Other causes might be the senescence of the Black Wattles which are all of about the same age, and reaching the end of their normal life span of around 20–25 years. Breeding seems to be continuing successfully, since new untagged animals have been found at each trapping. These replace losses due to death of ageing animals, and predation by owls, foxes and feral cats.

Sampling difficulties

Long-term identification of individual animals has proved difficult as the coloured metal ear-tags used on first release were soon torn off, perhaps in aggressive male interactions, so a program of ear tattooing was begun. This was not started until some ear-tags had already

been lost and tracing an identified ear-tagged animal to a later tattooed animal is not possible for some gliders. The tattoos also proved a problem, as they faded and were torn. The third attempt at secure identification has been by placement of microchips beneath the skin, but again, tracing tattooed individuals to later micro-chipped animals has proved difficult for most of the gliders. So there is limited continuity in the data and extracting life histories of survival and movement is frustrated by these gaps in the data. Population sampling during this study has been highly variable, with box inspections being carried out monthly from February 1989 to October 1992, and then only biannual trapping in 1993 and 1995.

Survival and status of Sugar Glider population at OPNP.

During one of the trapping programs in 1990 some of the trapped gliders were released at the south-eastern extremity of the OPNP. The gliders did not travel upstream towards the artificial nesting boxes but instead moved away from the park possibly towards a natural tree hollow in one of the many original River Redgums (Richard Leppitt *pers. comm.*). Dispersing individuals are known to go as far as 1.9 km (Suckling 1984) and so have the potential to move well outside artificial hollow and trapping locations in OPNP.

The age structure, population size (Fig. 6), reproductive success, survival and condition (Table 2) of OPNP gliders substantiate the conclusion that the species has been

successfully established as a self-regenerating population in the National Park. The population of Sugar Gliders has now persisted at OPNP for seven years. In the study period the size of habitat has expanded as young tree seedlings have matured to offer new territory for gliders, and the planted trees which were a maximum of 17 years old in 1989 are now seven years older and more capable of sustaining a glider colony. As the rainfall at Organ Pipes National Park is lower than Tower Hill or Willung the growth rate of these trees may be slower and not provide as much food. The most recent survey indicates that there are about the same number of gliders in the park as were released in 1989-90. From these findings, reports, that the minimal viable size required for a glider program was 2000 ha. (Juzva and Peeters 1992) now appear to be an over-estimate.

Future management implications

The data gathered during this project are relevant to the future management of Sugar Gliders at Organ Pipes National Park and to management of regenerating forest areas elsewhere in the state for the conservation of Sugar Gliders.

To ensure this survival there must be a planned provision of natural food sources. In the OPNP, these sources are *E. viminalis* in spring-summer and in winter are likely to be *Acacia* species (Suckling 1980; Suckling and MacFarlane 1983). The continued survival of Sugar Gliders at OPNP suggests there were adequate natural food resources during the study. The presence of Acacias capable of producing gum seems to be of great importance, at least to southern populations. Seven such trees are enough to sustain one Sugar Glider (Henry *et al.* 1989). The OPNP has a strict planting policy of using only local gene-stock. Self-seeding has been significantly affected by rabbits that are still a major problem, so the senescent mature Black Wattles, which are a major food tree, have not been replaced by maturing younger trees, and the food source is contracting. Senescence of wattles is very high and most trees are about 20 years old. This means a major regeneration program is needed to keep Sugar Gliders alive in the long term. Whether it is possible to replace the currently dying older trees with younger

trees in time to be used as a food source and thus ensure the survival of the current glider population remains to be seen.

Sugar gliders reduce their energy requirements in winter by huddling together in nest groups, so to survive in OPNP Sugar gliders need adequate shelter. Shelter sites must be provided in all areas where trees have reached 5–6 m in height, which will allow dispersing animals to find shelter in, and colonise all, areas of habitat that provide sufficient food.

Comparison of density of artificial hollows at Organ Pipes National Park (2.4–1.0 nos per ha) are comparable with densities recorded by Suckling (1984) at Willung (0.5–3.0 ha) and Tower Hill (3.0– 5.0 ha). The erection of more hollows at suitable sites should allow more *P. breviceps* to survive in the park. Recommended box density is 3–5 nest hollows per hectare, preferably clumped into groups (e.g. within a radius of 100 m).

Until such time as the planted trees at OPNP form hollows, it will be necessary to ensure that nest sites are provided and maintained in useable condition. Experience has shown that boxes need to be constructed soundly from a resilient type of wood to survive for many years out in the weather.

This study been shown that Sugar Gliders will use boxes designed for bats with the slit at the bottom of the box (Fig. 4) this has the advantage that bees do not swarm into these boxes. Recent studies also have indicated that fitting loose carpet to the roof of artificial hollows may stop bee infestation, but studies are only at the preliminary stage.

Further research is needed to document more accurately population variation of the Sugar Gliders at Organ Pipes National Park. Some studies are currently underway and those results should be published soon.

for advice on associated Sugar Glider research relating to this paper. (Permits RP-89-5) (RP-90-020)(901-095)(945-140)(901-095).

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Fauna Survey Group Contribution 20

A Note on Sugar Glider *Petaurus breviceps* Use of Brush-tailed Phascogale *Phascogale tapoatafa* Nests in Nest Boxes at Rushworth State Forest

Susan Myers[1]

The Fauna Survey Group (FSG) of the FNCV has been carrying out regular surveys at Rushworth State Forest in north-central Victoria for the last two years. Rushworth State Forest is the largest block of Box-Ironbark forest remaining in Victoria. However, tree felling continues in the forest for firewood and fence posts and for this reason large hollow-bearing trees are scarce in certain areas of the forest. A major part of the FSG work has concentrated on developing a picture of the status and distribution of the Brush-tailed Phascogale *Phascogale tapoatafa* using nest boxes as one tool to do this.

The original purpose of the nest boxes was to detect the presence of phascogales in the forest. Prior to this, the existence of the species in the area was not confirmed. The nest boxes, many of which were originally erected by T. R. Soderquist *et al.* in 1992, had been specifically designed to be attractive to phascogales (here 'phascogale' refers to *Phascogale tapoatafa*). To this end the diameter of the entrance holes are between 35 – 40 mm. This, coincidentally, also allows entrance to Sugar Gliders *Petaurus breviceps* which is a similar size to *Phascogale tapoatafa*.

The Sugar Glider (Fig. 1) is probably the most numerically common mammal in Rushworth Forest and makes ready use of nest boxes. They typically construct ball-shaped nests from green eucalyptus leaves in which a family group of three to eight animals shelter. At the age of 7 to 10 months, young Sugar Gliders leave the maternal group; sometimes females are recruited into the group in which they were born, but more often they, along with juvenile males, join other groups in adjoining areas. However, sometimes aggregations of juveniles will form their own group (Henry and Suckling 1984).

Phascogales, on the other hand, construct

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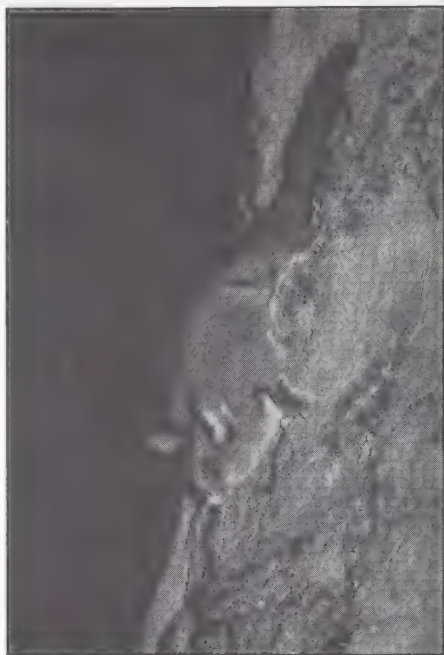
Fig. 1. Sugar Glider *Petaurus breviceps*.

nests of stringybark, feathers, wool and old leaves, although we have also noted the use of moss and lichen in some nests, in which rarely more than one adult animal shelters. Occasionally two to three juveniles have been recorded in a single nest. Phascogales generally have a 'toilet' containing large numbers of scats situated at the front of the box whereas Sugar Gliders are rarely found with scats in the box.

Over the last two years the FSG has systematically checked nest box contents every four to six months. On four occasions we have observed Sugar Gliders using phascogale nests. In December 1996 two observations were made: one nest box contained four Sugar Gliders in a phascogale nest, another contained two animals in a similar elaborate nest of wool, bark, moss and feathers. In June 1997 we

recorded two separate boxes, each with one Sugar Glider in a phascogale nest and we noted that the animals were alert and wary, bordering on aggressive.

We can only speculate at this stage about the reasons why Sugar Gliders may choose to occupy phascogale nests. Given that Sugar Gliders are particularly fastidious in regard to cleanliness within the nest (*pers. obs.*), it would seem to indicate some type of extenuating circumstance. All of the above observations were made in areas of forest with a paucity of hollow-bearing trees. Could it be that the animals are wandering, dispersing juveniles caught out at dawn with nary a vacant hollow in range?

Whether this sharing of nests occurs in natural hollows would no doubt be difficult to ascertain, although Traill (1993) has noted a high degree of inter-specific overlap in the use of hollows such as stumps and 'coppice hollows' at sites which lacked mature trees. This type of behaviour is no doubt worthy of further study and possibly indicative of the fact that something is wrong with our forests.

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Longevity of Yellow-bellied Glider *Petaurus australis*

Gary Slater[1]

A Yellow-bellied Glider *Petaurus australis* is believed to have set the longevity record for the species in captivity by living for over 14 years, at Healesville Sanctuary, Victoria.

As part of a research project being conducted on the socio-ecology of the Yellow-bellied Glider by Steve Craig of the former Fisheries and Wildlife Service, Victoria, an adult pair were housed at the Healesville Sanctuary on 21 September 1982, to develop a captive breeding strategy and to monitor the growth of pouch young. Both individuals were classed as adults on the basis of weight and total length (Craig 1985) and were, therefore, assumed to be at least two years of age (Russell 1984; S. Craig *pers. comm.*). There was advanced wear on the upper incisors of the male which suggested that he was older than two years, and the female showed evidence of recent lactation in the form of nipples of unequal length (Craig 1985). The male died on 1 December 1990, after having been at the Sanctuary for 8 years, 1 month and 27 days. The female died on 23 December 1996, after 14 years, 3 months and 5 days in captivity. Assuming the female was two years of age at capture, her age at death would then be over 16 years.

Russell (1984) observed deterioration in animals 5–6 years old which led to death, and Goldingay (1990) suggests the oldest animal in his study was six years of age. There is no doubt that animals which live in predator-proof enclosures and do not require the excising of tree bark, thus suffering continual wear on their teeth as they forage for food, will live longer than their wild counterparts. However, if three years longevity are removed from the female, as a reasonable extension of longevity that captivity affords, she would still have lived twice as long as any animal previously recorded.

During her years at the Sanctuary the female bred twice – the first time in 1988, which was the first recorded captive breeding of the species, produced a female, and the second in 1989 produced a male. The second birth signalled the apparent end of the female's reproductive life after nine years.

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Squirrel Gliders *Petaurus norfolcensis* at Warnock Reserve, Swanpool.

Greg Dennis[1]

Abstract

Squirrel Gliders *Petaurus norfolcensis* were recorded at Warnock Reserve, near Swanpool, 25 km south of Benalla when a dead tree felled for firewood was found to contain a breeding pair on the 8th of November, 1996. Their identification at this new location prompted a short study to determine the size and extent of the population within Warnock Reserve. The study was conducted over a one month period during November/December 1996, and resulted in one additional individual being identified. Further survey is required to determine if the *P. Norfolcensis* population still exists in nearby remnant vegetation. (*The Victorian Naturalist* **114**, 1997, 242-245).

Introduction

Warnock Reserve is a small (5.4 ha) reserve bisected by the Broken River, situated 25 km south of Benalla (Fig. 1). Two adult Squirrel Gliders *Petaurus norfolcensis* were identified inhabiting a dead tree felled for firewood on the adjoining 'Ooms' property (Fig. 2). The injured female was captured and the fatally injured male was collected and retained by the Department of Natural Resources and Environment (DNRE) at Wangaratta. The female was rehabilitated at the wildlife shelter operated by Raelene Dennis (permit No. 60-8-536) of Benalla and was subsequently released at Warnock Reserve.

Petaurus Norfolcensis is considered to be vulnerable in Victoria (CNR, 1993 in Menkhorst, 1995) and is listed as threatened under Victoria's '*Flora and Fauna Guarantee Act 1988*'. The purpose of this study was to determine the size and extent of the *P. Norfolcensis* population within Warnock Reserve, including the initial site on the adjoining 'Ooms' property. Prior to this, the Atlas of Victorian Wildlife shows the most recent record in the area as being on the 15th of April 1987, in the south-west corner of the Reef Hills State Park, approximately 18 km north-west from Warnock Reserve.

Study Area

On the western side of the Broken River Warnock Reserve has a slope with an eastern aspect that grades towards the river. On the eastern side it is much flatter, but still grades towards the river. Altitude varies between 210 to 220m. Australian Map Grid coordinates for the reserve are East 411700, and North 5929200 (topographic map reference: 8124-3-4 'Mount Samaria'). The reserve is accessible from the Midland Highway, 3 km south of Swanpool near Gandini Lane, or from Warnock Road on the eastern side of the Broken River.

Methods

Establishing Squirrel Glider presence

Because the reserve is bisected by the Broken River, observations were separately undertaken on the east and west sides.

Potential *P. norfolcensis* habitat was identified during daytime observations; especially hollows in trees which may constitute den sites, and where there was a possible food source such as Silver Wattle *Acacia dealbata* (Menkhorst, 1995). These sites were then observed by stag watching from early dusk to half an hour after dark with the observer remaining stationary and alert. Following completion of the stag watch the remainder of the area was surveyed by spotlight. Other species encountered were also recorded. The study period was between 8/11/96 to 11/12/96. During this period five stag watches were undertaken, each of approximately 1 hour's duration. A total of 4.5 hours were also spent spotlighting over the five nights at the close of stagwatching. The weather was fine for most of the survey time though misty rain occurred on one evening.
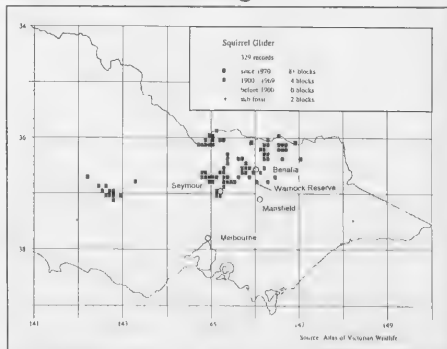
Fig.1.Squirrel Glider distribution in Victoria.

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Vegetation description

Information gathered was only sufficient to give a general overview of the vegetation types that exist within the reserve, with only dominant canopy and understorey species being recorded. Aerial photographs and topographic maps of the area were also examined in order to establish links between the reserve and other remnant vegetation.

Warnock Reserve - history and current use

Information was obtained from many sources, mostly in consultation with government authorities, adjoining land owners, and past land owners. A full list of sources used in compiling the history of Warnock Reserve is given in the acknowledgments.

Results
Stagwatching and Spotlighting surveys

Table 1 shows the *P. norfolcensis* results, and Table 2 shows the additional species that were encountered during surveys. Two adult *P. norfolcensis* were identified living near Warnock Reserve (the breeding pair from the felled tree). One adult was also identified within the reserve by spotlight, just prior to the release of the injured female. Despite stagwatching and spotlighting surveys no further trace of any animals could be found.

Vegetation types

Two vegetation types exist within Warnock Reserve. Red Box *Eucalyptus polyanthemos*/Red Stringybark *E. macrorhyncha* open forest exists from the Midland Highway to within 50 m of the Broken River on the western side. The remaining section to the eastern boundary is River Red Gum *E. camaldulensis* open forest. Yellow Box *E. melliodora* is scattered around the fringes of the *E. camaldulensis* on the western side.

Hollow trees

The availability of trees with hollows appears limited. There are only two old *E. camaldulensis* within the reserve which have significant hollows. The remaining trees are younger and appear to support much fewer hollows.

Understorey and ground layer.

The understorey is patchy with Silver Wattle *Acacia dealbata* being the most dominant shrub species, but closer to the river it is interspersed with River Bottlebrush *Callistemon paludosus*, Cumbungi *Typha* sp., and Bracken Fern *Pteridium esculentum*. Milkmaids *Burchadia umbellata* were identified amongst *E. polyanthemos* and *E. macrorhyncha* open forest. Many wild exotic fruit trees and willows exist on the river flats amongst the *E. camaldulensis* open forest. The ground layer throughout the reserve is dominated by weeds and introduced plant species, but these plants are most abundant where there are better growing conditions on the river flats amongst the *E. camaldulensis*.

Table 1. Squirrel Glider *Petaurus norfolcensis* records.

Date	8/11/96	8/11/96	11/11/96
Site	1	1	2
Tree habitat	Isolated stag in paddock	Isolated stag in paddock	Red Stringybark
Length	–	480mm	–
Weight	220g	260g	–
Count	1 Female	1 Male	1 Adult

Table 2. Additional species encountered

Species	Habitat	Count
Common Brushtail Possum *Trichosurus vulpecula*	Red Stringybark, Red Box River Red Gum	12 adults, 1 juvenile
Common Ringtail Possum *Pseudocheirus peregrinus*	Silver Wattle, Wild Apple tree	3 adults
Sulphur Crested Cookatoo *Cacatua galerita*	River Red Gum	large flock
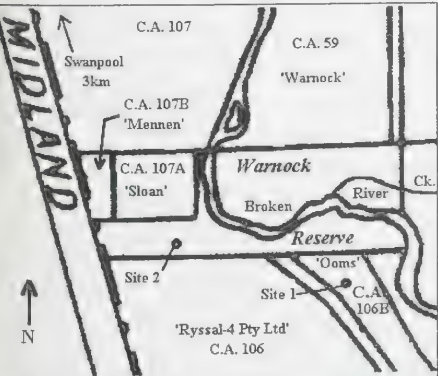
Fig. 2. Site plan of Warnock Reserve showing property boundaries, current land owners and crown allotment numbers, and the sites where Squirrel Gliders were identified. *(Plan source - Moorngag Parish Plan).*

Fig. 3. Young *Petaurus norfolcensis* that was fatally injured at Site 1. Fatal wound to top of skull is visible.

Fig. 4. *Petaurus norfolcensis* faecal pellets.

Links to other vegetation

The vegetation within Warnock Reserve connects the remnant vegetation on the roadside of the Midland Highway, to the remnant vegetation along the Broken River frontage, and the creek that enters the river from the east.

Warnock Reserve - History and current use

A grazing license (number 0296/130) once existed for the reserve (DNRE - Seymour), but it is unknown whether it was fenced off and grazed on a long term basis. It is known that since the 1940's it has been used as a stop-over by drovers (J. Dennis *pers. comm.*). There is little evidence of fire within the reserve, and according to current and past land owners (J. Dennis, E. Warnock *pers. comm.*) there have been no fires since the 1940's. The most recent disturbance was the 1993 floods which washed away some of the older trees (J. Erickson *pers. comm.*). The obvious lack of dead timber both standing and lying on the ground probably indicates the reserve has been used for firewood collection. The reserve is the responsibility of the DNRE and is classified as unreserved land. The Country Fire Authority recently instigated the upgrading of the track and river ford through the reserve to provide fire control access from one side of the river to the other. The track also provides access for adjoining residents and is maintained by

the Delatite Shire. Part of the reserve near the Midland Highway is slashed each Spring by the adjoining residents.

Discussion
Squirrel Gliders **Petaurus norfolcensis**

Given that the conservation status of this species in Victoria is vulnerable, the current record is of considerable interest. *Petaurus norfolcensis* have not been recorded in the area before, with the closest sightings recorded in the Atlas of Victorian Wildlife being in the Warrenbayne area, approximately 15 km south-west of Benalla, in the period between the 12th of May 1967 and the 15th of April 1987.

Site one (Fig. 2) represents the two initial *P. norfolcensis* records. The female at site one was carrying two pouch young which died from the trauma of the accident, but she survived and was released three days later. Figure 3 shows one of the fatally injured pouch young. Faecal pellets were collected from the injured female and are shown in Fig. 4. The male specimen (fatally injured at site 1) was in excellent condition with only minor damage sustained to the jaw. Figures 5 and 6 show dorsal and ventral views of this specimen.

As no further trace of *P. norfolcensis* could be found in Warnock Reserve since the two initial sightings at sites one and two, it is possible that there is now no population. Because of the seemingly high density of Brushtail Possums *Trichosurus vulpecula* and Sulphur Crested Cockatoos *Cacatua galerita* (Table 2), there may be intense competition for hollows. However, it is possible *P. norfolcensis* still exist within the reserve or in nearby remnant

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Fig. 5. Dorsal view of fatally injured *Petaurus norfolcensis* from Site 1.

Fig. 6. Ventral view of fatally injured *Petaurus norfolcensis* from Site 1.

vegetation; unless they are observed exiting their hollow at dusk they are very difficult to detect, as their eye shine is poor and their body colour gives them good camouflage amongst the foliage. Better results may have been achieved if surveys were also conducted in the remnant vegetation adjoining the reserve to determine if *P. norfolcensis* still exists nearby, but time constraints precluded this.

Conservation And Management

The remnant forest bounded by the reserve may be an important link for *P. norfolcensis* and other animals as it probably provides a corridor for wildlife. The DNRE is the authority responsible for the management of Warnock Reserve, and they have no specific management strategy for the reserve. It is infested with weeds and has a patchy understorey. However, any attempt to rehabilitate native vegetation would probably be an intensive and long term undertaking. With the knowledge that

P. norfolcensis have been recorded inhabiting Warnock Reserve, it is important to protect this habitat. The removal of a single nest tree or stag can dramatically affect the local persistence of a threatened species.

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Patterns in the Valley of the Christmas Bush:
A Seasonal Calendar for the Upper Yarra Valley

David Jones[1], Sharon Mackay[2] and Anne-Marie Pisani[3]

Abstract

There is a fallacy in the way we view time and landscape, and wrap it into the conventional four seasons. This is a northern hemisphere interpretation of the yearly cycles of one landscape and is strange to the Australian continent. Recently, especially through ideas from the Gould League and anthropologists in northern Australia, this abstraction of time has been questioned. Indeed, the research conclusions are that, depending upon the bio-region in Australia, there may be, in fact, between five to ten 'seasons' operating. The research inquiry re-confirms the Aboriginal divisions of time, and points to the signals it charted for their movements around their landscape. This paper reviews part of the background of the research inquiry and reports on a potential calendar for the Upper Yarra Valley region in Victoria. (*The Victorian Naturalist* **114**, 1997, 246-249).

Wattles Blooming

On the 15th of August, 1903, William Barak, elder of the Wurundjeri, died (Fig. 1). He foretold his death by announcing that it would occur when the golden wattles began blooming along the banks of the River Yarra. He attuned his senses to environmental cues which explained time, dates, and 'seasons' in a different framework to the European Gregorian calendar.(Wiencke 1984).

In Australia, we are hindered by the imposition of a European framework of Summer, Autumn, Winter and Spring, that
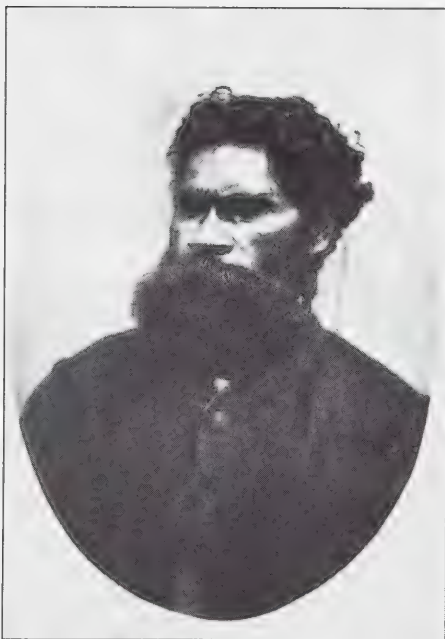
Fig. 1 William Barak, 1813-1903, last leader of the Wurundjerri clan. Photo courtesy Museum of Victoria, postcard courtesy Melbourne's Living Museum of the West, postcard loaned to us by Glen Jameson.

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Barak

At the age of 85 King William Barak, the last survivor of the Yarra Tribe.

Droops the wattles golden head,
Sigh the low winds, Barak's dead.
River gliding to the sea,
Gum bough whispering ghostily,
Stars that keep their watch on high,
Barak's dead.

King, and of his tribe the last,
Remnant of a vanished past,
He has seen the white man come,
Pitch his tent, and build his home,
Where his tribe were wont to roam,
He that's dead.

Oft beneath the stars has stood,
In primeval solitude,
Where the city hums today,
Then the bush slept, still and grey,
Kookaburras laughed and jay
Hailed the dawn.

Swings the world, and still pass on,
Ages, peoples, one by one,
Gumtrees whisper secrets old,
Life is but a tale that's told,
Barak's dead.

'Oriel' (John Sands). *The Argus* 17th August 1903 (Wiencke 1984).

fails to address the Australian natural system and climatic patterns. Barak, however, understood these events and patterns. This comprehension of the Valley's seasonal cycles, known by every Aboriginal community in Australia, triggered Aboriginal migration patterns, food harvesting activities, educational structures, fire burning occurrences and spiritual ceremonies.

John Sands, under the pseudonym of 'Oriel' wrote in *The Argus* after Barak's death a fitting poetic epitaph; words that draw out part of the seasonal clues for an Upper Yarra Valley calendar.

'Seasons' for the Aboriginal communities were not determined by days and years but by cyclic natural events. Campsites were shifted from the upper tributaries down to the banks of the Yarra and its perennial streams when the warm north-westerly winds arrived in the Yarra Valley. Boughs were cut to provide shelter from the Summer winds. A shift in winds was but one cue. The arrival of flowers on the Christmas Bush, the bloom of red fruits on the Native Cherry, the arrival of reddened inflorescences on the Kangaroo Grass, the flowering of Cumbungi reeds, and the breeding periods for the Wedge-tailed Eagle and Eastern Grey Kangaroo all signalled particular shifts and changes in the seasons for the Valley that determined Wurundjeri activities and relationships to this landscape.

Seasons: a plea for Australian Seasons

Seasons, in the European construct, are the loose dissection of northern hemisphere temporal patterns into four somewhat equal time compartments. The framework sits well in the northern hemisphere, but is very uncomfortable in the southern hemisphere. It is also difficult to apply it to Mediterranean climates, such as the Adelaide Plains, or to the wet tropics in Darwin and Kakadu. Our Australian natural history cycles, wildlife and plant associations, and climatic patterns operate in a different arrangement.

Aboriginals, in contrast, view environment in an integrated manner, reading landscapes in terms of plants, animals, soil types and climate, moon cycles, constellation movements within the frame of a fluid seasonal calendar. There can be somewhere between six to twelve main 'seasons' in Aboriginal 'calendars', with their own timespan depending upon the particular environment. Each 'season' is characterised by temperature, rainfall and wind direction that variously breaks the cycle into temporal periods analogous to our vernacular labels used to identify wet seasons, dry seasons, late dry seasons, breeding seasons and flowering seasons; each with its own Aboriginal name, set of events and happenings, and spiritual connections.

Landscape (land-based, sky-based and water-based) is read by Aboriginals in terms of entities analogous to our European land system and unit classifications. On the temperate volcanic plains of the Western District of Victoria, along the dunal fringes of the dry tropical landscapes near Broome, or in the wet tropical landscapes of Arnhem Land, each precinct or vegetation community holds a particular identity and name determined by its character and food harvesting resources (Jones 1993).

Within each vegetation community reside various foods – honey in tree trunks, Kangaroo meat and fat, tuberous roots including the Murnong (or Yam) and Chocolate Lily, native fruits, bird eggs, eels and fish, as examples.

The junctures of vegetation communities, especially near water sources, were favoured camp sites. Residency of sites was determined by the seasons and the cues of nature. Sites were often cross-linked to seasons through the necessity to re-ignite the manifestations and travels of spiritual ancestors.

Accordingly, Aboriginal camp and 'settlement locations were frequented at different times of the year according to food resource availability and the seasonal cycle. The early warm winds and crisp mornings of approaching Summer, for example, foreshadowed the migration of fattened eels down the Western District streams and rivers back to the ocean. At the same time Aboriginal communities congregated around these water courses and partook of extensive eel and fish harvesting. In the fresh Spring weather after the wet rains, they shifted back up to the volcanic plains and harvested flowering tuberous roots and berries, and hunted easy prey that was equally attracted to fresh

shoots and flowers.

In the wet tropics, people congregated along the coastal dune edges during the full wet seasons while grasses grew tall and the inland plains were under water. With the arrival of the dry season tribes ventured inland through the vine thickets to harvest plants and yams. As the plains dried out during this season, excursions inland became more regular and focused upon the larger swamps that were home to abundant plants, mammals and birds.

The seasons also hold spiritual connections. Events in the night sky foretold of happenings in the following daylight or provided signs of events. Myths were retold by way of components and voids in the night skies, and reiterated moral codes concerning Aboriginal land relationships and stewardship responsibilities.

Winds, birds and animals were often manifestations of great creation ancestors and, depending upon the moiety totems for the particular tribe or clan, their arrivals and departures signalled times for ceremonies or responsibilities. It was important to undertake crucial ceremonies at the right places at the right times of the cycle, and arrivals and departures were often temporal cues.

The complex set of moral codes associated with seasons also determined resource harvesting responsibilities: who harvested what food, how much and when; what was a protected, communal, gender- or age-specific resource, and when spiritual awakenings or nurturing ceremonies were performed. Fires were also ignited at particular times in varying sequences.

Climates and Calendars

Seasonal calendars varying between monsoonal, arid and temperate climates have obvious differences. Each is determined by temperature, rainfall and the biogeography of their region.

Stephen Davis, in *Arnhem Environ*, has formulated six main seasons for the Arnhem coastal region in a Milingimbi education kit, in consultation with the Yolngu community (Davis 1984). Occupancy in the Yolngu territory is strongly determined by marine resource availability. While each clan has responsibility for a distinct tract of land and sea, kinship relationships determined clan

movements throughout the territory depending upon the season and the abundance or dearth of palatable or staple food resources.

The Yolngu Calendar, consistent with most northern Australian coastal tropical Aboriginal communities, has six main seasons:

Dhuludur' (pre-wet season, October-November) when the weather is erratic, 'female' thunder and lightning storms are frequent, turtles and Threadfin Salmon are hunted, and the 'male' thunder shrinks the waterholes.

Bärra'mirri (growth season, December-January) when there are heavy rains and prolific plant growth, the Magpie Geese arrive and shellfish are harvested.

Mayaltha (the flowering season, February-March) when there are bright sunny days but little bush tucker, flies arrive and mosquito larvae are abundant in the pools.

Midawarr (the fruiting season, March-April) when the east wind signals a time of abundant bush foods, including fruits, nuts and barramundi.

Dharratharramirri (the early dry season, May-July) when the trade winds (south-southeast) arrive, the bush is fired, Magpie-Lark flocks arrive and sharks and stingrays give birth.

Rarrandharr (the dry season, August-October) when warm southeast winds blow, the soil is hot, young sharks and stingrays are hunted, and the stringybark flowers.

Seasonal calendars are now available for the temperate Swan River coastal plain (Bindon 1992), and for the wet tropic localities of Yolngu, Aurukan, Cape York, Jabiru and Broome. Work on compiling a calendar in temperate zones is extremely limited.

Alan Reid, through the Timelines Australia Project, has proposed a six season calendar, assuming the premises inherent in Davis' calendar, for the middle Yarra Valley (Reid 1995).

Research work, however, undertaken with the Wurundjeri of the Upper Yarra Valley near Coranderrk has pointed instead to seven cyclical seasons and two infrequent but overlapping seasons. This calendar, devised in consultation with Yarra

Yarra elders of the Wurundjeri, draws upon information about animals, animal breeding and hibernating cycles, and flowering phases as well as the influence of temperature, rainfall, wind, star and moon movements and Yarra Yarra moiety totems. Changes in landscape and environs indicate each new season.

Aboriginal names are yet to be attached to individual seasons but their European titles, and temporal spaces, are deliberate. They include:

Apple Season (December) when the weather is warming, the Pleiades are rising, Peron's Tree Frogs are laying their eggs, the Kangaroo Apple is ripe, and Kangaroo Grasses, Christmas Bushes and Black Wattles are in flower.

Dry Season (January-February) when the Valley is drying, and Eastern Grey Kangaroos are breeding, Wombats are seen at night, Native Cherries are ripe and the Growling Grass Frogs are restless.

Eel Season (March) when the eels migrate downstream in the River, Cumbungi and Swamp Gums are in flower, 'woof - woof' calls are heard from the Barking Owl, Tiger Snake eggs are seen and Brushtail Possums are breeding.

Wombat Season (April-August) when the Common Wombat becomes more active and basks in the sun, when Lyrebirds perform courtship displays, Wedge-tailed Eagles enter their breeding cycle from late June to early July, and Silky Hakea and Silver Banksia are in flower. The rainfall increases, and Bush Rats are seen indulging themselves with food.

Orchid Season (September) when orchids, Flax Lilies, Prickly Currants, Murnongs, Native Geraniums and Flat Peas are in flower, Pied Currawongs are singing while Tree Goannas are excavating egg-laying mounds.

Tadpole Season (October) when tadpoles are prolific. Orchid Season plants continue their flowering, Dusky Antechinus give birth and Growling Grass Frogs lay their eggs.

Grass Flowering Season (November) when the Kangaroo Grass and Christmas Bush begin to flower, Orion arrives, and most of the Orchid Season plants are at the end of their flowering periods.

Two 'seasons' are missing from this 'calendar'. When each occurs the seven calendar seasons are altered but eventually shift back to their original positions. These 'seasons' are:

Fire 'Season' (approximately every 7 years) when a medium to hot burn from a deliberately ignited bushfire or lightning strike burns part of the Valley.

Flooding 'Season' (approximately every 28 years) when the River Yarra rises over its banks and floods the Yarra Glen–Launching Place reaches.

Context of Calendars to Landscapes

While our design palette may consist of both exotic and indigenous plant species, the growth of each is determined by seasons. Similarly, our planting and harvesting choices are occupied not just by humans, but by animals, insects, birds and aquatic life whose life cycles are much more closely linked to seasons.

However, in Australia our planting guides and a large part of our natural history and fire monitoring records are premised incorrectly upon the four European seasons. We need to abandon these calendars and devise seasonal calendars appropriate for each region we design within in Australia.

The seasonal calendar is a representation of the changing activities of the sky, weather, plants and animals.

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From our Naturalist in Residence, Ian Endersby

Spider Stories

The Zoological Catalogue of Australia, at least for some of the invertebrate groups, is a stimulus for future studies rather than a definitive listing. Volume 3 contains pseudoscorpions, whip spiders, the mygalomorph spiders and about half of the araneomorph families. There is obviously lots of work yet for the taxonomists and also for the naturalist interested in spider behaviour and distribution. Let's have a look at a couple of examples.

The Two-tailed Spiders (family Hersiliidae) are so named because of their long protruding spinnerets. Unlike most spiders the hersilids have the openings to the silk glands on the sides of the long spinnerets. They live on tree trunks and, when they detect their prey, they stop it moving by putting a spinneret on either side and engulf it with silk by whirling rapidly round and round, facing away from the prey. Another distinguishing feature is the third pair of legs which are much shorter than the others.

The Zoological Catalogue lists four species for Australia: *Tama brachyura*, *T. eucalypti*, *T. fickerti* and *T. novaehollandiae* but none of them had been recognised in Victoria. I found this surprising as I had seen females on local smooth-barked eucalypts. They are extraordinarily well camouflaged but when the sun strikes them at an angle in the early morning they sometimes stand out. All of the early examples that I saw were females on the eastern side of tree trunks. I thought that perhaps this might be due to some thermoregulation behaviour but I don't have enough examples to be sure. They seem to establish a preferred spot, usually in a small depression and return to it after a feeding foray or when disturbed. Eventually a small pad of silk builds up on their resting place.

Since the catalogue was published a lot of work has been done on this family by overseas taxonomists. Firstly, the genus *Tama* became *Tamopsis* and the species *brachyura* and *novaehollandiae* were no longer recognised because the type specimens were either lost or of immature specimens. However, 26 new species were described mainly from Western Australia and Queensland; four supplements later the Australian total stands at 50 species and there are now some Victorian records.

A juvenile female specimen of *Tamopsis eucalypti* from Merrijig was recognised, and two juvenile females from Cockatoo and Bemm River were possibly *T. fickerti*, but they were not sufficiently identifiable to make the official list. Both of these species are known from southeast Queensland, coastal New South Wales and South Australia with one, and possibly both, also present in Victoria. What then was my specimen? Here we face the dilemma of making further behavioural observations or taking the specimens for identification. I lingered too long and they disappeared.

Every Lemon-scented, Spotted or River Red Gum that I pass I now check and have found hersilids on all three species as well as on some introduced Marlock trees which are a smooth-barked eucalypt introduction from Western Australia. Finally a female specimen I gathered from Sale visited Germany to be told that it was the first mature adult of *T. eucalypti* from the State. Hersilids are identified primarily from the reproductive organs of the males, but one of the other distinguishing features for the two Victorian possibilities is the eye area: *T. fickerti* has a high ocular tubercle while *T. eucalypti* has a low one. Recently I saw a male hersilid out probably seeking a female. As the sun caught it in profile it seemed to have a very obvious eye hump. I am sure that the Victorian Hersiliidae story is not yet complete.

Another spider which ventured indoors came from the family Zodariidae and was recognisable as a member of the genus *Storena* from its high clypeus, two rows of strongly curved eyes and the yellow abdominal spots as pictured in one of

Ramon Mascord's books. The Catalogue listed only two species for Victoria: *Neostorena venatoria* and *Storena macedonensis*, so it was sent to the Museum for identification. A most unexpected answer came back; a new monograph on the genus had recently been published and the spider was *Storena colossea*. Previously this species had been listed only from Lord Howe Island.

Records for the genus *Storena* in Victoria now comprised *S. formosa*, *S. cyanea*, *S. charlotte*, *S. recurvata*, *S. colossea* and *S. nana*. We seemed to have lost *S. macedonensis* in the revision. Another puzzle was the locality for *S. charlotte* 'Charlotte Waters, Soyter's River, Camp 4' and that for *S. recurvata* 'Glenvy, Vic'. For both of these species their main distribution is nowhere near Victoria: Mornington Island for *S. charlotte* and southern Queensland for *S. recurvata*. Charlotte Waters was one of the repeater stations on the Overland Telegraph line and it was situated near the South Australian/Northern Territory border but is not marked on many maps. Nearby is Goyder's Creek which eventually flows into the Finke River, and it

doesn't take much imagination to see the connection. I checked the label in the Museum and found it to be written in a script handwriting on a browned paper. It seemed quite obvious to me that it was originally misread. The specimen is the holotype so the type locality should be Central Australia, not Victoria. Glenvy and *Storena recurvata* probably hide a similar story but I cannot locate an alternative Glenvy yet. Nevertheless I believe both of these two species should be removed from Victoria's faunal list.

That is not the end of the story. A further revision of the genus appeared and it recognised that the Victorian and New South Wales specimens recently attributed to the Lord Howe Island species *S. colossea* were really a new species named *Storena mainae* so *S. colossea* really does just belong on Lord Howe. One final note: *S. macedonensis* turned up in another revision of the whole family as *Habronestes macedonensis* and a new species was listed for the State, *Habronestes bradleyi* – we lost some and we won some.

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Spiderwatch
A Guide to Australian Spiders
by Bert Brunet

Publisher: *Reed Books, Port Melbourne, Victoria 3207, RRP $24.95.*

'Spiderwatch' is a handbook following closely on the heels of 'The Silken Web', also by Bert Brunet. It is a condensed version of the latter. Sections of text in both books appear almost identical, but with some rearranging of sentences and wording. Some chapters or contents appearing in 'The Silken Web' are not included in 'Spiderwatch' or have been condensed and incorporated elsewhere. However, 'Spiderwatch' has additional sections on 'Where to find spiders' which includes collection of spiders, and 'Drawing, photographing and making notes'. A section on 'Australia's Dangerous Spiders' with first aid procedures is excellent, but recent work, throwing doubt on the White-tailed Spider's ability to produce necrotic bites, has not been included.

Most of the illustrations and photographs are the same in both books. Some photographs have been cropped, reversed or inverted while the illustrations of the Sydney Funnel-webs have been touched up as the abdomen of those presented in 'The Silken Web' were too naked and glossy in appearance. Captions are also more concise.

Colour coding of the page edge enables each section to be found readily. A visual key to the general shape of many families is given, but I have problems associating some of these drawings with the relevant spiders as I know them, particularly those of *Deinopis*, *Badumna* and '*Stiphidium*' (which should be *Stiphidion*). *Argyrodes* is shown as one representative of the Theridiidae and we are referred to p.142, but the text for *Argyrodes* is on p.154. Unfortunately, many errors such as this occur.

An attempt has been made to rectify the taxonomic errors present in 'The Silken Web', but some still exist, and new errors added. *Steatoda livens* (originally described from Tasmania) is referred to as a domestic species, but this status belongs to *S. grossa* and *S. capensis* (photographs of the latter species appear on page 166 of 'The Silken Web').

As in 'The Silken Web' the Araneomorphs are divided into Open-range hunters, Ambushers and Anglers, Apprentice weavers and Master weavers. Bert Brunet has persisted in calling orb-webs, 'wheel-webs' and the only reference to 'orb' is in 'Golden Orb-weaver' which incidentally makes a 'wheel-web'. I find it disconcerting that the Garden Orb-weaver, as it has been known for many years, is now referred to as 'Garden spider' making a 'wheel-web'.

The Huntsman spider, *Isopoda immanis* in 'The Silken Web', is now correctly referred to as *Holconia immanis*. However, the Huntsmen on p.53 and p.114 referred to as *Holconia* sp. are *Isopeda* sp. Confusion surrounds *Isopeda vasta*, which appears as *I. vasta* on p.45 and *Holconia vasta* on p.114, and in fact these photographs are likely to be of *Isopeda villosa*. A description of *Neosparassus diana* given in the text does not correspond with the photograph (p.118) captioned as that species and which is, in fact, a photograph of *N. punctatus*. The photograph captioned *N. punctatus* on p.119 is not that species.

Contradicting the statement on p.74 'Don't play with names', new common names are applied to the Badge Huntsmen, *N. calligaster* and *N. punctatus*, 'Speckled' and 'Brown' respectively, but looking at the drawings it appears these common names are transposed. *Delena cancerides* has been given the name 'Red-brown Huntsman' which would be more aptly applied to some *Isopeda* species. Social Hunstman would be a more suitable name for *Delena*.

As 'Spiderwatch' is a condensed version of 'The Silken Web' those purchasers who already have a copy of 'The Silken Web' will be disappointed with the lack of fresh subject matter. As a field manual, (stated on the rear cover), it fails to live up to the standard set by the late Ramon Mascord. While I find the text fluent, unnecessary repetition of passages is rife. Observations on habits and behaviour are generally good, but too many errors occur in the text for the book to be considered a vast improvement on 'The Silken Web', or as a valuable handbook on Australian spiders.

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A Field Guide to Insects in Australia
by Paul Zborowski and Ross Storey

When CSIRO published the second edition of *Insects of Australia* in 1991, it recognised about 86,000 named species of insects and associated hexapods (collembola, protura and diplura). These were found in 31 orders and 662 families with three-quarters of the species belonging to the three orders coleoptera (beetles), lepidoptera (butterflies and moths) and hymenoptera (wasps, bees and ants). Over 1 million is the figure usually quoted for the number of named insect species in the world with a long way to go to describe them all. Such a diversity forces the professional entomologist to specialise in a circumscribed group; how, then, can the field naturalist hope to put names to those insects collected or photographed?

There seems to be two ways of identifying things in the natural world: botanists and entomologists are heavily dependent on keys; ornithologists and mammalogists generally use distinguishing field marks. With patience and careful observation the characteristics of each insect order can be learnt and used successfully but determining the succeeding taxa can be difficult, although some families are very distinctive. Paul Zborowski and Ross Storey have produced a guide which helps a lot because it takes the obvious field marks out of the keys and illustrates them.

After introductory chapters on external anatomy, life cycles, crypsis and mimicry, and collecting, the *Field Guide to Insects of Australia* presents a key to the orders and then discusses each of them in detail. Using the headings: Characteristics of Orders; Life Cycle; Biology; Classification; Further Reading; the authors produce a succinct introduction which gives an overall picture of the order and allows the identification of its more common or unusual families. Superb macrophotography complements the text and makes one feel confident that if the insect were seen in the field it could be recognised, a task that is difficult with guides that use pinned specimens for illustration.

About half of the insect families in Australia are beetles, bugs, wasps or flies so let us see how the authors handle these groups. They have chosen 21 of 113 beetle families which include nearly 85% of the named species. Distinguishing features, behavioural characteristics and likely locality, together with a photograph give lots of clues to each of the families. Obviously atypical forms will not be readily identified but many of the typical ones will.

Three-quarters of Australia's bugs are contained in the 31 (out of 99) families that the authors have selected while the figures for flies are 60% (18 out of 98 families) and between 50 and 60% for wasps (14 out of 63 families). Add in the smaller orders and the butterflies and moths and you have a very good coverage of Australian insect families. However this does not guarantee that you can to identify an insect from one of the illustrated families, as they still show a large range of morphological diversity. Normally I frown upon people who try to identify insects from picture books but if you read the text of this book as well as look at the photographs you have a very good chance of confirming that your specimen is from the family involved; occasionally you will be lucky enough to get the genus or even species shown unequivocally.

The authors are both professionals in the field (with CSIRO and QDPI) and their list of acknowledgments is a who's who of Australian entomology, so there are no doubts about the authenticity of the book. The second printing edition carries a Whitley Award Winner emblem signifying exemplary design and format and it is a handy size to carry in the field.

If you are curious about insects because of their behaviour, their role in ecological niches, or just because they are colourful and often bizarre, then this book will be an easy introduction to the orders and a substantive guide to the families. You can then tackle the detailed literature from a surer base.

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Grasshopper Country: The Abundant Orthopteroid Insects of Australia
by D.C.F. Rentz

As for many groups of insects in Australia, the grasshoppers and their allies are easily recognised to general form, but details of their systematics and biology are not well known to most naturalists. With *'Grasshopper Country'*, the first major handbook to this complex array of insects in Australia, David Rentz has accomplished a task initiated some 20 years ago with the publication of one of the best illustrated and most clearly written books available on Australian insects. His encyclopedic knowledge, his love of the Australian environment and sense of wonder at the biological extravagances it has generated, and his remarkable photographic skills are combined elegantly in this splendid volume. The book summarises knowledge of four associated orders of insects (Orthoptera, Blattodea, Mantodea, Phasmatodea) but includes also many original observations and a digest of material ranging from the highly technical to natural history observations which will be a boon to the less experienced enthusiast.

The major evolutionary and systematic features are introduced in the first chapter, with a succinct survey of the complex higher classification of the orthopteroids. Dr Rentz also stresses the value of Orthoptera as 'flagship taxa' for conservation, a topic on which he has written more extensively elsewhere - (*'Orthopteroid Insects in Threatened Habitats in Australia'*. pp. 125-138 in Gaston, K.J., New, T.R. and Samways, M.J. (Editors) *'Perspectives on Insect Conservation'*. Intercept, Andover, 1993).

Chapter 2 deals with the techniques for collecting orthopteroids, Chapter 3 with rearing them, and Chapter 4 with preparation and study. From the comment at the start of Chapter 2, it seems that these were initially intended to form a single chapter, but the separate sections flow well, provide much practical advice, and the copious illustrations are a valuable aid to the text. Rentz points out the considerable advantages of nocturnal collecting and notes that use of the fluorescent wand 'reduces the hazards of stepping on a snake, or falling into a hole, or off a cliff' - a comment which could come only from a highly experienced field collector! The use of a bat detector to discover vocal katydids will be novel to many readers. Techniques for rearing nymphs to adulthood will also be valuable to many naturalists, and a recipe for an artificial diet for non-predatory species is included in an Appendix. The sections on study and specimen preparation are clear and comprehensive and should lead to considerable increase in the quality of specimens taken by non-specialists - anyone contemplating collecting orthopteroids should read this text carefully. Although genitalic examination and the study of stridulatory files is the domain of the specialist, such techniques reflect the increasingly sophisticated appraisal needed for species determination in many groups of our insect fauna, and underpin the need for critical identification in economic entomology, conservation assessment and a multitude of allied applications. Simply, Australia cannot condone further erosion of its taxonomic expertise if we are to fulfil our international obligations to document biodiversity adequately.

Part 2 of the book comprises nine chapters on different groups of Orthoptera, and Part 3 devotes a chapter to each of the other three orders. They are to a standard format, so that it is relatively easy to compare information on the various groups. Chapter 5 commences with a key to suborders to Orthoptera and tabular synopsis of the Australian fauna (2744 species), with introductory notes on biology. Keys are presented in context to superfamilies, families, subfamilies, tribes, and in many groups to genera, presenting a synoptic treatment of the Australian fauna far more detailed and informative than any hitherto available to non-specialists and reflecting

the author's great contributions to understanding our orthopteroids.

All the chapters are comprehensively illustrated. Many of the whole insect drawings are from *'The Insects of Australia'* (1991, Melbourne University Press) but are augmented by others as well as numerous original photographs of whole insects and structural features. Each group is introduced by a discussion of recognition and diagnostics, features of the Australian fauna and general biology. This is then followed by broad outlines of more specific systematics and habits. I learned much from these chapters, in which many complex themes are treated clearly, and the needs for future work are emphasised. Thus, we read (p. 176) that more than half our species of typical grasshoppers (Acrididae) are unnamed, and the sentiment that one of the main reasons for this book (endorsing prefatory comment) is 'to attempt to stimulate interest in grasshoppers and encourage their further study'. But the writing is such as to inspire confidence in the reader: Rentz' enthusiasms are infectious and pervasive, and his authority ubiquitous in this lucid and informative text. Comprehensive references, and appendices on photography, special interest groups through which the reader can contact other enthusiasts and increase his/her knowledge, and 'recipes' are followed by a useful glossary, and a clear index. The 425 colour photographs are an invaluable part of this book.

The importance of sound in recognition and systematics of Orthoptera is now universally accepted, and also plays a part in the biology of Blattodea and Mantodea, and indeed probably influences most insects. In 1965, the doyen of European Orthoptera workers, D.R. Ragge, produced a book on the British species which was accompanied by a vinyl record of their songs, then an innovative production which proved of great use for students. To accompany the present book, CSIRO has produced an audio CD containing the songs of more than 100 species - many here available for the first time. This disc, (which is separately available at $40 from CSIRO publications, but is supplied with the book if purchased from them), is recommended strongly as part of the biological identification kit for these insects, and will help naturalists recognise many of the hitherto strange sounds encountered in garden and bush.

'Grasshopper Country' is excellently designed and strongly bound and sets a high production standard in a subject area of considerable interest and relevance in the developing study of insect biology in Australia. Great care has been taken to write in simple, clear English so that the stated aim of writing for two levels of interest, general readers with an interest in nature, and more advanced readers such as graduate students and professional entomologists, is admirably fulfilled. The publisher's claim that the book is a milestone in Australian entomology is by no means exaggerated and, in comparison with many other recent natural history books, the price is very reasonable for a volume of lasting national and international significance.

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Errata

In Volume 114(3), 159-161, the photograph used for Fig. 2 in the paper on 'Muellerina and Other Mistletoes of Southern Queensland' was not supplied by the author (Gillian Scott) and is not of *Muellerina bidwillinii* growing in *Callitris* but is of *Amyema cambagei* growing on a *Casuarina* species.

We apologise for any misunderstanding this has caused.

Victorian Butterfly Database

Publisher: *Viridans Biological Databases Version 1 1996; RRP $120.00*

This CD ROM is the second of Viridans Flora and Fauna Databases and follows their previous successful release of the *Victorian Flora Database* CD-ROM. The *Victorian Butterfly Database* is an impressive CD-ROM which brings the viewer detailed biological, conservation and distributional information on Victoria's currently known 129 species of butterflies. In the context of this work, the butterflies include the Family Hesperiidae (skippers) which account for 39 of the 129 species. The database includes the endemic as well as regular and occasional lepidopteran 'visitors' to the state of Victoria, and is up-to-date in that it includes a butterfly yet to be formally described and given a scientific name, the Mildura Ogyris, and the recent generic name change of the Caper White from *Anaphaeis* to *Belenois*.

Many Victorians would be surprised to learn that there are 129 recorded butterflies from Victoria. A commonly heard statement from the public, when describing a butterfly is, 'the small blue ones' or, 'the large brown one' etc. This CD-ROM will enable most people to identify butterflies to the generic level and to the species level for many of the Pieridae and Papilionidae butterflies simply by comparing a live insect with the colour images available from the CD-ROM.

The very existence of this CD-ROM must be credited to two of Victoria's most respected and experienced amateur naturalists. Both David Crosby and Nigel Quick have an impressive track record on the biology and conservation of Victoria's butterfly fauna. They have individually and jointly prepared several reports and management plans for the Department of Natural Resources and Environment on Victoria's endangered or threatened butterflies including the Altona Skipper *Hesperilla flavescens flavescens*, the Victorian 'Ant Blues' *Acrodipsas myrmecophila* and *Acrodipsas brisbanensis*, and the Eltham Copper *Paralucia pyrodiscus lucida*. David Crosby was also the entomologist who described and named the Eltham Copper in *The Victorian Naturalist* 67 (1951), 225-227.

The distribution data is derived from three sources: 40% from David Crosby; 40% from Nigel Quick, and 20% from the Museum of Victoria. Most of the pictures were scanned from photographs supplied by Nigel Quick (136) with the balance provided by Mike Coupar (38), David Crosby (33) and Robert Fisher (2).

Loading the CD-ROM onto a computer is a simple process, which is detailed in the inside cover of the CD-ROM. Different Setup files, selectable from the Windows 'Run' menu, must be used according to the operating system in use - Windows 3.1 or Windows 95. The CD-ROM was tested on a 166 MHz Pentium with an 8 times CD-ROM running Windows 95, as well as a slower DX2-66 Intel computer with a 2 times CD-ROM running Windows 3.11. Both computer systems were equipped with a SVGA card and monitor configured to display 64 thousand colours. Understandably, the performance of the DX2-66 system with 2 X CD-ROM was relatively slow. The most resource intensive processes are searching for species in a given area and displaying the images of the Land Use - High Resolution maps. The time taken to display the Land Use - High Resolution map was also slow on the Pentium system. It is recommended that on slower computer systems, a simple map such as outline of Victoria is chosen as the time taken to read the CD-ROM and display the image will be greatly reduced.

The opening screen of the CD-ROM consists of several large 'click on' buttons over a spectacular colour image of the underside of the hindwing of the Imperial White butterfly *Delias harpalyce*. The main menu includes three large buttons which open the main operating screens of the CD-ROM package i.e. 'Search for a Species', 'Search an Area' and 'Select a Map'. Different maps can also be selected from the 'Search for a Species' and 'Search an Area' menus. Additional buttons leading to 'Help', 'Software Credit', 'Exit' and 'Information'

screens are also provided.

The simplest way to get to know the capabilities of the CD-ROM is to select the 'Search for a Species' button. This will take the user to a screen which displays a table of four listed species one of which will include a medium sized colour image of the species. Any of the 128 Victorian species can be selected by using the Page Up and Page Down buttons and mouse. Clicking the 'Big Picture' button will then display a full screen image of a photograph of perfectly set specimens. Many species have several additional photographs of live adult, egg, larvae and pupae of the species. The nine photographs of the Eltham Copper *Paralucia pyrodiscus lucida* are particularly outstanding and comprehensive.

After viewing the full screen photographs of the selected butterfly clicking the 'Back to List' button will return the user to the main 'Search for a Species' screen. Clicking on the 'Distribution' map will then display the geographic distribution of the species on one of the maps in 10 x 10 minute latitude and longitude grids. This is the same grid system which was developed by Nigel Quick for the ENTRECS scheme of the Entomological Society of Victoria in 1975. There are 13 maps upon which the 10 x 10 minute grids can be plotted. The most useful map would probably be the roads and towns map. The maps are of interest in their own right as the mouse cursor can be set at any location on the map to read off information such as rainfall isohyets, elevation within 200 and 400m contours, land use, soil type, and vegetation provinces.

Images are all of excellent quality yet are just in 256 (8 bit) colours with only a few showing a checkerboard pattern due to the limited colour palette. This lack of full colour information is noticed only in the backgrounds of some images and in the patterns of some of the Satyrniid butterflies.

An added bonus with the CD-ROM is the facility to print, with a suitable printer, five colour posters of the life cycles of the five butterfly families. These are excellent introductory posters which depict the life cycle of a typical member of each family showing its habitat preference, foodplants, behaviour and several images of representative members of the family. An excellent, fourteen

page Word for Windows document, with in-line images, can also be printed from the CD-ROM. This document gives a concise summary of the basis of the distribution data, family characteristics, conservation status and biological relationships between the butterflies and their foodplants.

Because the issue of the use of common names can be a contentious one among professional entomologists and serious amateurs, the use of scientific names is preferred in order to avoid mis-identification. The use of common names does cause confusion, for example *Hesperilla flavescens flavescens* is given the common name Yellowish Skipper in the CD-ROM. However, the Friends of the Altona and Skeleton Creek refer to the same butterfly as the Altona Skipper. It is interesting to note that a search under the name Altona Skipper does indeed return the name *Hesperilla flavescens flavescens*. Two of the target audiences of the CD-ROM would have to include Primary and Secondary Schools and it would present a daunting task for these students to be comfortable with, and be able to correctly pronounce, some of the scientific names of the Victorian butterflies, particularly when amateur naturalists also have difficulty with the pronunciation. The intention to make the CD-ROM appeal to a broad audience is believed to be the reason that all the butterflies have been given a common name, though that would be a misnomer as, in many cases, the butterflies in question could certainly not be considered as common.

The search facility can be used to generate and print a checklist of recorded species for invertebrate surveys or, where no records exist, to add to the distribution knowledge of butterfly species by physically searching for species. Common butterflies such as *Zizina labradus*, the Common Grass Blue and *Pieris rapae*, the Cabbage White would certainly be found in many of the grids to the west of Melbourne where no records are presently found.

The list of recorded species from native vegetation areas, particularly accessible montane regions, would have a high probability of including all the endemic taxa due to the many years of observing and collecting activities in these fauna rich locations. David Crosby's data from these areas

would be the foremost in the state due to his many years of surveying and conservation work in Victoria.

A few shortcomings of the CD-ROM must be mentioned. These were the salient problems I detected. Some of the following may be readily changed but others could require a change of software which may require considerable effort to implement.

- Some sections of the software do not display species' scientific names in italics. This is also evident in other software programs examined in the course of preparing this review i.e. *Insects a World of Diversity* – CSIRO and *Australian Cicadas* – Australian Museum; Max Moulds.
- PgUp and PgDn on keyboard does not mirror the screen buttons in the 'Search for a Species' screen but does in the 'Search an Area' screen. Right hand scroll bar is not available in the 'Search for a Species' screen.
- There is no 'Previous' or 'Try Again' button on some menus e.g. when making a mistake on the 'Type Name' species search window, there is no 'Try Again' button, which then requires a two step process to try again. This may seem trivial but is important when typing in an incorrectly spelt scientific name as the current version of the software does not appear to have any spell check feature and the offered 'Best Guess' suggestion usually bears no relation to the intended search.
- There is no exit button in the 'Change Map' screen. Once a new map is selected, the small 'Change Map' button must be used to exit the screen. This is not an expected use of the button.
- Tilting of some Little and Big Pictures up to 5 degrees on some examples detracts from the overall high quality of the CD-ROM images.
- A guide to the picture layout of the first 'Big Picture' image of each species, i.e. male and female, above and below, would be better displayed with the actual images and not 'buried' in the fifteenth screen in the 'Information' menu.

The CD-ROM should be of interest to Primary and Secondary Schools, Conservation and Natural History Groups, individual amateur naturalists as well as professional entomologists. Natural

History Groups could make use of the CD-ROM as a checklist when undertaking surveys. Unfortunately, any checklists generated from the CD-ROM can only be printed at the time of search and are not able to be saved in a word processor document. This facility would be useful when preparing a survey or excursion report. The CD-ROM was used by the Entomological Society of Victoria to print a list of the recorded species for the Kinglake region. This list was then used as a checklist against the species recorded during a survey of parts of the Kinglake National Park (under permit) held in December 1996. In the north eastern part of the Park, only one of the species from the CD-ROM generated list was recorded. However, seven species not listed were found.

Victorian Schools and, in particular, Secondary Colleges would find a use for the CD-ROM. It contains detailed biological and distributional information together with excellent colour images all of which could not be readily obtained from any single reference source. The CD-ROM is not a multimedia introduction to the world of butterflies but a source of genuine up-to-date, scientific information. The fact that the information is current may result in some aspects of the CD-ROM becoming dated. Viridans should investigate some form of low cost upgrade of early versions of the CD-ROM, since the current distribution records, in particular, have the potential to become out-of-date by targeted survey work.

The unique feature of the *Victorian Butterfly Database* is that it specifically targets the Victorian species and this makes the viewer more able to relate to the product. Libraries and bookstores already have an abundant number of books about insects from overseas. Even books on Australian insects tend to be dominated by the often showy and spectacular tropical species from the Torresian biogeographical regions of Australia. Paul Gullan, the team at Viridans, Nigel Quick and David Crosby are to be congratulated on making the biological and distributional information in the *Victorian Butterfly Database* available to the public.

Daniel Dobrosak
66 Wiltonvale Avenue, Hoppers Crossing,
Victoria, 3029.

Obituary
David George Dunn
1911-1997

Many members, especially those in the Botany Group, were saddened to hear of the death of David Dunn on 3 August 1997, at the age of 86.

David, as his wife Ilma, were members of the Native Plants Preservation Society when it was suggested to them that they should also become members of the Field Naturalists Club of Victoria. They were elected in the early 1970s, and became very active in the Botany Group, taking part in both meetings and excursions. Ilma is a keen photographer, and David was frequently seen providing backup, with tripod and other equipment.

The position of Honorary Treasurer remained vacant at the Club's AGM in 1980. Dan McInnes, the retiring Treasurer, persuaded David, who had been Treasurer of the Native Plants Preservation Society since 1970, to take on the task. This he did in December 1980, and was re-elected each year until 1984. David was a most thorough and conscientious Treasureer, and he huided the Club through finacially difficutl times, when membershiop was declining. I became Honorary Secretary in 1982, my first involvement in the administative affairs of the Club, and I was very grateful for his help, always most willing given, in dealing with problems. Council members, and others, will remember David as a very kindly and gracious gentleman.

David's main interest was in amateur radio, and he was a licensed member of the Wireless institute of Australia, preferring to use Morse code. In his association with the Native Plants Preservation Society he gave invaluable support to their annual 'Photoflora' exhibitions, supplying equipment and recording commentary and music for the programmes. Ilma was responsible for the slides and David provided the aural component.

David and Ilma were a team, and we extend our sympathy to Ilma in her sad loss.

Sheila Houghton

Geoff Monteith

Winner of the 1997 Australian Natural History Medallion.
The Council and members of the FNCV extend their
congratulations to Geoff for this achievement.

The Presentation of the Medallion will take place on 10 November at 8 pm in the FNCV Hall, 1 Gardenia Street, Blackburn Victoria 3130.

After the presentations, Geoff Monteith will talk on 'Living with Insects'.

The FNCV Council extends a warm invitation to all its members and their guests, and hopes that they will be able to attend such a prestigious event.

For more information, contact Sheila Houghton on (03) 5428 4097.

Computer Team: Alistair Evans and Anne Morton
Labels: Felicity Garde
Web Page: Michael McBain

The
Victorian
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From the Editors

The Victorian Naturalist would not be successful without the enormous amount of time and effort voluntarily given by a large number of people who work behind the scenes.

The
Victorian
Naturalist

Editors: Ed and Pat Grey

Cover: Aseroe rubra photographed by Ron Fletcher at Lankey's Plain
(see p. 286, 289).

Simple Colour-Coded Field Key to
Common Lichens of Victorian Coastal Areas

Simone Louwhoff[1] and Kathleen Ralston[2]

Abstract
Species of twelve lichen genera, *Buellia. Caloplaca, Flavoparmelia, Lecanora. Lichina, Parmotrema. Physcia. Ramalina, Teloschistes. Usnea, Verrucaria* and *Xanthoria*. are well represented in coastal areas such as rocky shores and coastal sand dunes. A colour-coded field key to these species is provided. This key is based upon the colour of the upper surface and the type (general structure) of the lichen. Ecological notes on coastal lichens are also included. (*The Victorian Naturalist*, 114, 1997, 264-268).

Introduction

Many lichens are associated with particular habitats, for example, rainforests, arid areas and mangroves. Similarly, the occurrence of distinctly coloured lichens at the seashore has been noted by scientists and naturalists alike. This article, with colour-coded field key, aims to assist field naturalists with the identification of many lichens commonly occurring on sand dunes and rocky shores of Victoria's coastal areas.

Background information

A lichen is a composite organism consisting of two, or sometimes three, partners which live in close association with one another. One of these partners is a fungus (referred to as the mycobiont) and the other a green alga (chlorophyte) and/or a cyanobacterium. Lichens are classified with the fungi in the kingdom Eumycota. The fungus provides shelter, moisture, nutrients, determines the overall shape of the lichen and usually provides the sexual reproductive structures. Fungi are unable to manufacture their own food and the algal partner contributes this function to the relationship through photosynthesis. This association of fungus and alga is a very successful one and lichens are able to grow on nearly any substratum and inhabit almost any environment.

Lichens can be categorised by their growth form and traditionally three main types are recognised: fruticose (3-dimensional and 'shrub-like'), foliose (2-dimensional and 'leaf-like') and crustose ('blotch-like'). These different growth forms have different characteristics which are used in lichen identification.

[1] National Herbarium of Victoria, Melbourne, Birdwood Avenue, South Yarra, Victoria 3141.
[2] Residential address: 1/79 Stanhope Street, Malvern, Victoria 3144.

There has been an estimated 20,000 lichen species recorded worldwide (Filson 1992) of which approximately 2,800 have been reported from Australia (Filson 1996). Filson and Rogers (1979) *Lichens of South Australia* and the *Flora of Australia* Volume 54 (1992) both provide a useful introduction to lichens and the latter also includes a systematic arrangement of Australian lichens (Rogers and Hafellner 1992).

Some ecological notes on coastal lichens

Clear zonations of lichens occur on rocks in aquatic environments (Hale 1967; Purvis *et al.* 1992). Which particular lichens occur where depends on their different resistances to submersion, drought, water quality (Kappen 1973; Thrower 1988) and, along the coast, on the amount of sea-spray and wind received (Purvis *et al.* 1992). The chemical and physical nature of the substratum influence rock-inhabiting lichens (McCarthy 1994) and lichen zonation appears more obvious on siliceous rather than on calcareous shores (Fletcher 1976) although there is little evidence of research on coastal lichens and geology.

Along rocky seashores three distinct zones of lichen communities are evident: the intertidal zone where lichens are temporarily or permanently submerged, and two zones above this, not subject to tidal action, but affected by high water and spray (Hale 1967; Purvis *et al.* 1992). The intertidal zone is dominated by species of the black, crustose lichen *Verrucaria* which tolerates wave action but not permanent inundation (Kappen 1973). Further away from the sea, and avoiding wave action, the black fruticose *Lichina confinis* occurs. Above this zone are the orange lichens, *Caloplaca* and *Xanthoria*.
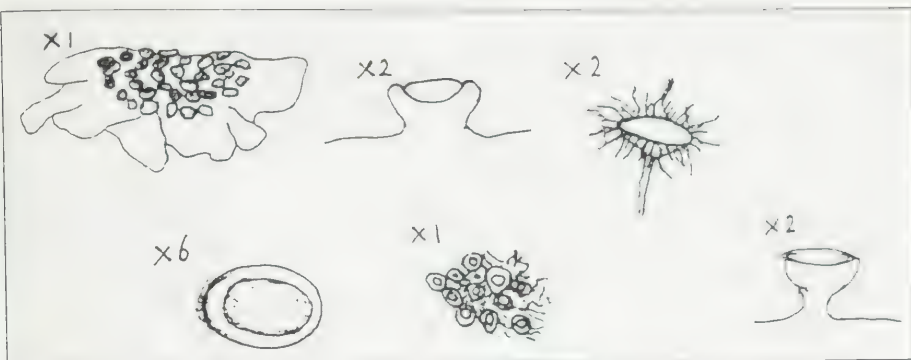
Fig. 1. Different types of fruiting discs observed on coastal lichens.

The lichen family Teloschistaceae is well represented along the coast, and also in the drier parts of the country. Some of its members have a remarkable tolerance to salt (Kappen 1973) and *Xanthoria parietina* can be found even on salt-rich substrates such as branches of Scrubby Glasswort *Sclerostegia arbuscula* in salt marshes. The one characteristic displayed by all three representatives of Teloschistaceae along the coast is an orange thallus. According to Weber (1977), lichens occurring in well-lit or exposed situations have more intense pigmentation of the cortices, which may protect the algal layer from harmful amounts of light. Species of *Xanthoria* occurring along the coast display this characteristic with a predominantly orange upper surface and green marginal lobes when these are wrapped around the branch.

Unfortunately, many of the Victorian bayside suburbs no longer support as rich a lichen flora as was observed earlier this century. This could be attributed to increased levels of air pollution to which many lichens are very sensitive, particularly species of *Ramalina* and *Usnea* (Rogers 1992). Fruticose and some crustose species are the first to disappear, followed by foliose lichens (Rogers 1992).

While there have been several studies on lichen communities of rocky shores, there appears to be little research on lichens of coastal sand dunes, although collections on some offshore New Zealand islands by Hayward and Hayward (1982a, b, 1984) and a study by Stevens (1979) on coastal mangroves does provide some insight into coastal lichens other than those of rocky shores.

Notes on the key

Previously, identification of lichens was almost restricted to the specialist since keys were either too technical for the amateur lichenologist or absent all together. Unlike most traditional lichen keys, this field key is based, firstly, on the colour of the upper surface of the lichen and secondly, on their general structure. In addition, the colour of the raised fruiting body, usually shaped like a disc (Fig. 1), is provided to aid with identification. Technical terminology is avoided to make the key more 'user-friendly'.

The key was developed based upon collections made as part of a larger ecological study at Breamlea, Victoria (by K. Ralston) and upon examination of specimens lodged at the National Herbarium of Victoria, Melbourne. The key is intended for identification of common lichens of Victoria's rocky shores and sand dunes and may also be relevant to mangroves (Table 1).

The 'Flora of Australia' Vol 54 (1992) and Vol 55 (1994), and Filson and Rogers (1979) 'Lichens of South Australia' may be referred to for illustrations, although the reader should be aware of some name changes.

Collecting techniques followed that of Filson (1992) and Louwhoff (1995). Nomenclature follows Rogers and Hafellner (1992).

Using the key

The key requires the following steps in identification:

1) Observe the upper surface of the lichen and turn to correct colour section (NOTE: colour sections are based upon field observations, not dried herbarium specimens).

    1) Green (including grey-green and yellow-green)

    2) Grey/White

    3) Black

    4) Orange

2) Once in the correct colour section, locate the matching lichen type:

***Crustose*:** like a 'blotch' or crust and tightly attached to, or embedded in, the substratum.
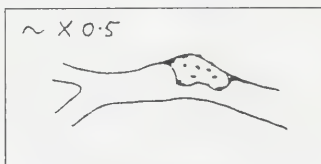
Size: very variable

***Foliose*:** mostly 2-dimensional, leaf-like, flat, horizontally spreading, with an upper and lower surface.
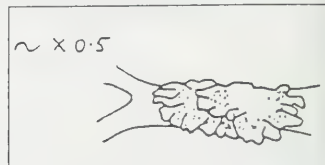
Size: very variable

***Fruticose*:** 3-dimensional, bushy, shrub- or branch-like, erect or hanging.
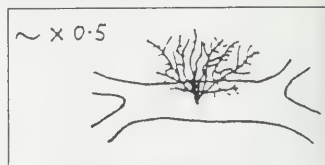
Size: very variable

3) Match the lichen to the individual descriptive entry.

4) Refer to Table 1 for species list. This list is based on field specimens and specimens at the National Herbarium of Victoria, Melbourne.

Simple Colour-Coded Field Key to Common Lichens of Victorian Coastal Areas

1. GREEN
(including grey-green and yellow-green)

Foliose

On bark: grey-green with bluish hue, ruffled appearance, with powder-like substance (soredia) on upper surface. Disc brown (very rare). Lower surface black, becoming brown at margin. Root hairs (rhizines) black.

Parmotrema chinense
(PARMELIACEAE)

On bark: yellow-green, wrinkled. Disc brown. Lower surface dark brown with naked margins.

Flavoparmelia rutidota
(PARMELIACEAE)

On bark or rock: yellow-green to golden-orange, flat. Disc orange, margin of disc usually distinct.

Xanthoria
(TELOSCHISTACEAE)

Fruticose

On bark: erect or hanging, lobes flattened and strap-like or hollow and inflated. Fruiting body on short stalk, disc buff or greenish-yellow; margin prominent.

Ramalina
(RAMALINACEAE)

On bark: thread-like, erect or hanging. With tough central axis.Yellow-green disc, hairs usually present on margin of disk.

Usnea
(USNEACEAE)

2. GREY-WHITE

Crustose

On bark or rock: white, cream or buff-grey, grained or warty. Disc black or grey with a black margin.

Buellia
(PHYSCIACEAE)

On bark or rock: white to greyish-white. Disc usually darker grey, margins greyish-white and prominent.

Lecanora
(LECANORACEAE)

Foliose

On bark: grey-white, sometimes with distinctly hairy margins (hairs white or pale brown but never black). Underside pale. Disc dark grey to purple, with crystal-like powder on surface.

Physcia
(PHYSCIACEAE)

On bark: grey-green with bluish hue, ruffled appearance, with powder-like substance (soredia) on lobe margins. Disc brown (very rare). Lower surface black, becoming brown at margin. Root hairs (rhizines) black.

Parmotrema chinense
(PARMELIACEAE)

3. BLACK

Crustose

Immersed in sandstone rock in intertidal zone or coastal dune limestone. Black, forming gelatinous film when moist, with small warts.

Verrucaria
(VERRUCARIACEAE)

Fruticose

On rock in marine splash zone.Black, more or less erect, with densely clustered branches. Disc small, immersed in tips of branches.

Lichina confinis
(LICHINACEAE)

4. ORANGE

Crustose

On rock or bark: crustose or scale-like, yellow to orange-red. Disc yellow to orange, on surface or immersed.

Caloplaca
(TELOSCHISTACEAE)

Foliose

On bark or rock: flat, yellow to golden-orange (at times greenish around margin). Disk orange.

Xanthoria
(TELOSCHISTACEAE)

Fruticose

On bark: yellow-orange (occasionally somewhat green at base). Disc concave to flat, yellow or orange, often hairy thereby giving lichen overall 'fuzzy' appearance.

Teloschistes
(TELOSCHISTACEAE)

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Table 1. List of lichen species commonly occurring in Victoria's coastal regions, including likely presence on bark and/or rock (based upon field observations and specimens lodged at the National Herbarium of Victoria, Melbourne).

Species	Bark	Rock	Species	Bark	Rock
Buellia stellutata		*	*P. aipolia*	*	
Caloplaca citrina		*	*Ramalina canariensis*	*	
C. flavorubescens		*	*R. celastri*	*	
C. halocarpa	*		*R. fissa*	*	
C. saxicola		*	*R. glaucescens*	*	
C. vitellinula		*	*R. inflata*	*	
Flavoparmelia rutidota	*		*R. inflata* spp. *australis*	*	
Lecanora caesiorubella	*	*	*Teloschistes chrysophthalmus*	*	
L. crenulata		*	*Usnea inermis*	*	
L. dispersa		*	*U. scabrida*	*	
L. sphaerospora		*	*U. undulata*	*	
L. varia	*	*	*Verrucaria maura*		*
Lichina confinis		*	*V. microsporoides*		*
Parmotrema chinense	*		*Xanthoria ligulata*		*
Physcia adscendens	*		*X. parietina*	*	

The Victorian Naturalist

The Grey-crowned Babbler *Pomatostomus temporalis* on the Mornington Peninsula – Going, Going, Gone?

David Lockwood[1] and Doug Robinson[2]

Abstract

The Grey-crowned Babbler was a moderately common and widespread bird in the Mornington Peninsula region of Victoria until about 1950. Its numbers have subsequently decreased rapidly and only six groups, or a total of thirteen birds, are now known to persist, the population having decreased by 65% in the past eight years. Historically, the Grey-crowned Babbler was closely associated with a lowland grassy woodland of Snow Gum, rough-barked Manna Gum, Narrow-leaved Peppermint and sheoaks. By 1870, nearly all of that vegetation type had been extensively modified and it is suggested that the loss of that preferred habitat type was the initial cause of the babbler's decline. The subsequent decline has occurred as a result of many different processes such as habitat fragmentation, isolation and increased predation. Although the extinction of this species in the Mornington Peninsula region appears inevitable, we emphasise that conservation of the surviving remnants of grassy woodland on the Mornington Peninsula is essential for the conservation of other, smaller species of woodland-dependent wildlife (e.g. invertebrates, plants). A range of possible conservation measures is proposed. (*The Victorian Naturalist* **114**,1997, 269-277).

Introduction

Early records suggest that the Grey-crowned Babbler *Pomatostomus temporalis* was once a moderately common bird on the Mornington Peninsula, Victoria, and its surrounds (Wheelwright 1860; Shepherd 1902; Campbell 1905; Lang 1948; Davis and Reid 1975; W. Jones, *pers. comm.*). Now it is endangered both locally (Schulz 1991) and statewide (CNR 1995).

Schulz (1991) summarised the recent status of all known populations of the Grey-crowned Babbler on the Mornington Peninsula and southeast of Melbourne. He estimated that of the 18 groups recorded to be alive in the 1960s-1980s, nine still survived in 1989, the known population consisting of 31 birds. In this paper we provide an update on the further decline of the Grey-crowned Babbler on the Mornington Peninsula and nearby districts. We try to place that decline in context by providing additional historical information on the bird's past status, local distribution and habitat associations. Some new information on the species' biology is also presented.

Methods

Historical records of the Grey-crowned Babbler were obtained from *The Atlas of Australian Birds* (Blakers *et al.* 1984), Campbell (1900), North (1909), Mathews (1923-24), ornithological and natural history journals, observers' records and museum collections. Recent records were sought from observers' records, the *Atlas of Victorian Wildlife*, Schulz (1991), and requests for assistance in the local media. Between 1991 and 1995, every site identified by Schulz (1991) as having had groups of babblers in the last three decades was visited at least once. Extensive searching was also carried out in areas of suitable habitat on private properties, golf courses and Crown land reserves. We played tapes of babbler calls at most sites to try to attract any birds still present there.

We determined the broad habitat preferences of the Grey-crowned Babbler by plotting records onto vegetation maps of the Mornington Peninsula (Calder 1986). More detailed habitat information was obtained by recording the species, abundance and size of trees and shrubs, and the composition of the ground layer at existing sites. We also noted the locations of recent nests at all surveyed sites.

Feeding behaviour was recorded by watching individual birds and recording the time they spent feeding in each component of the habitat. Each observation period was then treated as a single sample within which we scored whether a particular category of feeding behaviour occurred or not (e.g. feeding on the ground, feeding on the trunk, feeding on the branch).

Eucalypt taxonomy

Three forms of Manna Gum *Eucalyptus viminalis* are found on the Mornington Peninsula: a tall, white-trunked form

[1] 'Friends of the Grey-crowned Babbler', c/o 12 Alexander Avenue, Clayton, Victoria 3168.
[2] Birds Australia, 415 Riversdale Road, Hawthorn East, Victoria 3123.

which grows in gullies, on basaltic soils and in areas of higher rainfall; a form with rough bark on the lower trunk and smooth upper trunk and branches which is most common in open-forest formations occurring on sedimentary-derived soils; and a small form with mostly rough bark which occurs on sandy soils (Calder 1986). The latter form is now classified as a distinct sub-species, Coast Manna Gum *E. viminalis pryoriana*, but may hybridise with the rough-barked form of *E. viminalis* (Walsh and Entwisle 1996; *pers. obs.*). Wherever we refer in this paper to the rough-barked form of *E. viminalis* or to presumed hybrids between the rough-barked form and *E. v. pryoriana,* we have used the collective name 'Manna Gum', while *E.v. pryoriana* is separately referred to as Coast Manna Gum.

Results
Historical status
Wheelwright (1860) wrote that the 'Mocking bird' was 'not very common; generally in small flocks in secluded places among the honeysuckles and shey oaks'. Nonetheless, the fact that a person travelling on foot recorded multiple flocks implies that the Grey-crowned Babbler was then widespread. A spate of records from around 1900 further intimates that it used to be a rather common species. Between 1896 and 1909, Grey-crowned Babblers were recorded from Tooradin, Frankston, Mornington, Langwarrin, Cranbourne, Shoreham and Kananook (Table 1). In the same period, Shepherd (1902) and Campbell (1905) both commented on how the species was becoming more common, Campbell (1905) writing that 'We are glad

to notice how plentiful the large and useful babbler is becoming..'.

In the subsequent thirty years, between about World War 1 and World War 2, the Grey-crowned Babbler remained quite common, although some observers began to record a decline in about 1930 (O. Dawson *in litt.*). At Clyde, babblers were regularly observed in the hedges of Hedge Wattle *Acacia paradoxa* which bordered paddocks between 1919 and 1930. They disappeared following the clearing of the hedges in about 1930 (O. Dawson, *in litt.*). In the Coolart-Somers area, birds were commonly seen along Coolart drive until about 1940. They were also recorded from nearby roads (Jones, cited in Davis and Reid 1974; Davis and Reid 1975). Elsewhere in the region, Grey-crowned Babblers were frequently observed at Woodlands Golf Club at Mordialloc (Lang 1948; Wheeler 1949), where '...groups would average about ten birds in number' (Lang 1948); Tyabb (R. Gibson, *pers. comm.*); Baxter (Lang 1948) and Seaford (Cox 1936). A local resident growing up in the Moorooduc area during this time recalls that they were a common bird, especially in the sheoak areas on the Moorooduc plains (W. Jones *pers. comm.*).

After World War 2, the Grey-crowned Babbler began to disappear rapidly and, by 1970, was described as 'just holding on' (Wheeler 1970a). The few literature records for the period 1940-1970 comprise sightings from Moorooduc (Amos 1949), Baxter (Wheeler 1967), Somerville (Thomas 1968), Langwarrin-Baxter (MacDonald 1971) and Mt Martha (Wheeler 1970b). Since 1970, numbers of

Table 1. Historical records of the Grey-crowned Babbler on the Mornington Peninsula.

Locality	Year	Observer/Collector	Reference
Cranbourne	1896	H.R. Stevens/NMV	RAOU Atlas
Tooradin	1899	R. Hall/AMNH	RAOU Atlas
Tooradin	1899	R. Hall/NMV	RAOU Atlas
M. Peninsula	1900	S. Townsend	Davis and Reid (1974)
Mornington	1902	H.L. White	RAOU Atlas
Shoreham	1902	J.A. Kershaw	Kershaw (1902)
Frankston	1902	A.G. Campbell/AMNH	RAOU Atlas
Somerville	1902	G. Shepherd	Shepherd (1902)
Kananook Creek	1904	H.L. White	RAOU Atlas
Somerville	1905	A.G. Campbell	Campbell (1905)
Langwarrin	1906	C.F. Cole/AMNH	RAOU Atlas
Frankston	1908	C.F. Cole/AMNH	RAOU Atlas
Frankston	1908	L.G. Chandler/AMNH	RAOU Atlas
Mornington	1909	L.G. Chandler/AMNH	RAOU Atlas

Table 2. Land tenure and group size information for Grey-crowned Babbler groups recorded in the southern Melbourne region in the past ten years.
The first nine records are those listed in Schulz (1991); the remaining records are of groups which have since been found, although some of the latter may include groups recorded by Schulz and which have relocated their territories.
Key: [1] = 12 birds in 1979; [2] = 15 birds in 1983; [3] = 5 birds in 1992; [4] Schulz's group and the currently-known group may in fact be two different groups in which case, the former group recorded by Schulz is now extinct; [5] 4 birds in 1992.

Site	Location	Land Tenure	1987-89	1993	1995	1997
1	Rosebud	Golf course	2	2	2	2
2	Balnarring	Gardens/roadsides	2	2[5]	2	2?
3	Hastings West[4]	Gardens	3	2[3]	2	2
4	Mt Eliza South	Public reserve	3	0	0	0
5	Mt Eliza North	Gardens	7	2	2	2
6	Cranbourne	Golf course	5	?	0	0
7	Cannons Creek	Gardens/roadsides	2[1]	0	0	0
8	Keysborough	Golf course	4	0	0	0
9	Mordialloc	Golf course	3+	5	5?	3
Sub-total			**31+**	**13**	**13**	**11**
10	Mt Martha	Farm/roadsides	3?	3	2	2
11	Mornington	Farm/roadsides	7[2]	3	3	0
12	Endeavour Hills	Golf course	2?	2	1	0
Total number of birds			**43+**	**21**	**19**	**13**

the species have diminished further and its status has changed from that of a rare species (Mitchell and Mitchell 1975; Andrew *et al.* 1984) to regionally endangered (Schulz 1991) and endangered statewide (CNR 1995).

Recent Changes in Status

Schulz (1991) listed nine surviving groups of Grey-crowned Babblers and a total of 31 birds in 1989. Of those nine groups, four have since become extinct (Table 2), the number of groups thereby shrinking by *c.* 44% in just eight years. Individual birds concurrently decreased from an estimated 31 birds in 1989 to 11 individuals in 1997 - a decrease of 65% (Table 2). Set against these losses has been the recent discovery or re-discovery of another group, hence increasing the size of the known population to six groups and a total of 13 birds (Table 2). (*Note*: two additional groups that were discovered have since become extinct). Of the six groups now known, five consist of two or fewer individuals (Table 2) and none has reared young in the past two years.

Broad habitat preferences

As suggested by Wheelwright's writings, and observations by local naturalists (W. Jones *pers. comm.*), the Grey-crowned Babbler was evidently most common in open forests and woodlands (Wheelwright 1860). Of 39 known past and present localities, 72% (28) are in a floristic association characterised by Snow Gum *Eucalyptus pauciflora* and Manna Gum or Narrow-leaved Peppermint *E. radiata* (Fig. 1), with a scattered understorey of smaller trees such as Drooping Sheoak *Allocasuarina verticillata*, Black Sheoak *A. littoralis*, Cherry Ballart *Exocarpos cupressiformis*, Silver Banksia *Banksia marginata*, Black Wattle *Acacia mearnsii* and Blackwood *A. melanoxylon* (Opie *et al.* 1984; Calder 1986; Yugovic 1993; *pers. obs.*). The remainder of the localities are (or were) in associations of Messmate *E. obliqua* Narrow-leaved Peppermint Manna Gum open forest (3 localities), Silver-leaved Stringybark *E. cephalocarpa* Messmate peppermint woodland (2 localities), Messmate open forest (2 localities) and heathy woodland (4 localities).

Specific habitat preferences

The specific habitat needs of the Grey-crowned Babbler on the Mornington Peninsula are difficult to determine now because of extensive modification of the habitat and isolation of surviving groups in vegetation types which may have been unsuitable historically but have become more suitable as a consequence of habitat
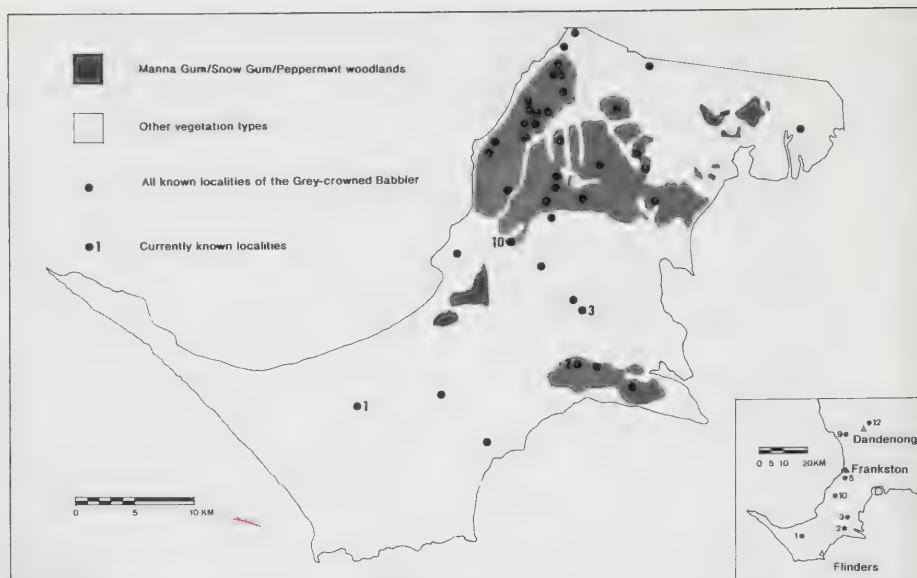
Fig. 1. Historical and present localities of the Grey-crowned Babbler *Pomatostomus temporalis* on the Mornington Peninsula in relation to the former distribution of Manna Gum/Snow Gum/Peppermint woodland and other vegetation types. Vegetation boundaries were derived from Map 9 in Calder (1986) and represent the distribution of her floristic unit 18. Note that the southeastern area of woodland vegetation (around site 2) never included Snow Gum woodland but was more likely a Peppermint woodland (Calder 1986).

alteration (e.g. the conversion of some heathy woodland sites to woodlands with a grassy understorey because of pasture establishment) or necessity. Notwithstanding these caveats, it seems useful to provide information on the structure and floristics of the vegetation present at contemporary sites as a guide for habitat restoration activities in the region.

As Table 3 shows, the majority of sites occupied by Grey-crowned Babblers contained an overstorey of indigenous eucalypts, particularly Manna Gum or Swamp Gum *E. ovata*. At Sites 1 (Rosebud) and 3 (Hastings West), no indigenous eucalypts were present at the observed feeding sites and the overstorey consisted either of Monterey Pines *Pinus radiata* or exotic eucalypts and other non-indigenous trees. Regardless of whether the trees present at every site were indigenous or not, the trees present typically had rough bark with crevices (e.g. Monterey Pine, Manna Gum, Coast Manna Gum, Southern Mahogany *E. botryoides*) or else were smooth-trunked but with peeling bark (e.g. Swamp Gum, Blue Gum *E. globulus*).

A second habitat feature common to most

of the existing babbler sites was the presence of some large shrubs (Table 3) that were used variously for foraging, nesting and shelter. The most common indigenous species recorded were Black Sheoak, Blackwood, Black Wattle and Cherry Ballart. Most often, though, Babbler sites contained the non-indigenous but native Coast Tea-tree *Leptospermum laevigatum*, Giant Honey Myrtle *Melaleuca armillaris* or Prickly-leaved Paperbark *M. styphelioides* (NB: Coast Tea-tree is only indigenous to the coastal fringe of the Mornington Peninsula and is considered to have invaded or been introduced to inland areas, Calder 1986). The third habitat feature common to all of the sites was low grasscover, usually less than 5 cm high. As a result, birds had ready access to the ground layer for foraging.

Foraging behaviour

Grey-crowned Babblers mostly foraged on the ground (52% of records, n = 58), particularly on areas of short grass close to shrubs or trees. They also spent some time foraging in the branches and at the base of the trunk of indigenous tree species (31%),

Table 3. Summary of the vegetation present at current or recent Grey-crowned Babbler sites. Sites are listed as in Table 2.
Key: * − sampling was incomplete due to the extensive home range of the Babbler group (Sites 1, 3 and 11) or precise locality of the now extinct group is unknown (Sites 6 and 8). + − presence of that plant species at the site

Plant species present	1*	2	3*	4	5	6*	7	8*	9	10	11*	12
E.v. pryoriana					+		+		+			
E.v. viminalis		+		+	+					+	+	
E. ovata		+		+	+					+		+
E. pauciflora					+					+		
E. radiata		+		+						+		
E. camaldulensis						+		+	+			
Allocasuarina littoralis			+	+				+	+			
Other indigenous trees			+	+				+	+	+		
Non-indigenous trees	+	+	+	+	+		+		+	+	+	+
Indigenous shrubs		+		+	+		+		+	+		
Native, non-indigenous shrubs	+	+	+	+	+				+	+	+	+
Introduced shrubs		+			+							
No of indigenous trees > 60 cm dbh	0	3	0	2	7	?	0	?	12	100	3	1
No. of exotic trees > 60 cm dbh	?	0	6	0	2	?	0	?	5	1	3	10

and in various other trees and shrubs (17%). The tree species used by the birds comprised Manna Gum, Coast Manna Gum, Narrow-leaved Peppermint, Swamp Gum and Snow Gum. Previously, they have been observed foraging on the branches of Monterey Pine and Monterey Cypress *Cupressus macrocarpa.*

At the five most highly modified sites for which foraging records were collected (Sites 2, 5, 9, 11, 12, see Table 3), a large proportion of foraging time was spent on the ground (79%, n = 43 observed birds, total observation time = 167 minutes). Furthermore, of the time spent foraging on trees or shrubs, 90% was on shrubs and only 10% was on indigenous trees, the most popular shrubs being Coastal Tea-tree and *Melaleuca* spp. It is worth noting that despite the birds at Site 9 having access to many mature River Red Gums *E. camaldulensis*, none was observed to forage in these gums but instead foraged mostly on the ground (92%, n = 23 observed birds, obs. time = 70 minutes) or, occasionally, on the few Coast Manna Gums present. By comparison, at the most natural site (Site 10), babblers foraged mostly on the bark of the four eucalypt species (74%), less often on the ground (26%) and not at all on shrubs (n = 15 observed birds, total obs. time = 31 minutes). For those observations

of birds foraging in trees at Site 10 (n = 12), 100% were of birds foraging in trees larger than 60 cm diameter at breast height (dbh) and 64% were of birds foraging in trees larger than 120 cm dbh, even though smaller eucalypts were much more common (Table 4).

Nesting locations
Every nest found (n = 15) was less than 7 m above the ground and most were built 3-5 m up in a small tree or shrub about 5 m high. The nest tree species did not appear to matter as nests were recorded from eucalypt saplings, mature eucalypts, oak *Quercus* sp., Cypress, Black Sheoak, Drooping Sheoak, Prickly Paper-bark, Giant Honey-myrtle, Hop-bush *Dodonaea* sp. and Coast Tea-tree. Local naturalists growing up on the Mooroduc Plains in the 1930s and 1940s mentioned finding nests in Cherry Ballarts, 'lightwoods' (probably Black-woods and especially sheoaks (W. Jones, D. Shepherd, *pers. comms*).

Discussion
Comparative ecology of the Mornington Peninsula population of Grey-crowned Babblers
Considerable research has recently been conducted on Grey-crowned Babblers on the Northern Plains, where the species is likewise declining but is more widespread

Table 4. Summary of the vegetation present at the Mt Martha site (Site 10).

| Plant species present | Size classes (trunk diameter at breast height in cm) | | | | |
	> 90	60-90	30-60	10-30	<10
E. viminalis	+	+	+	+	+
E. ovata	+	+	+	+	+
E. pauciflora	+	+	+	+	+
E. radiata	+	+	+	+	+
Total no. of eucalypts	**31**	**66**	**110**	**115**	**66**
No. of *Allocasuarina littoralis*	1	1	2	36	88
No. of other indigenous trees	1	1	4	58	154
Total no. of indigenous trees	**33**	**68**	**116**	**209**	**308**
Total no. of exotic trees	**0**	**1**	**5**	**6**	**1**
No. of indigenous shrubs	0	0	0	13	228
No of native, non-indigenous shrubs	0	0	1	83	17
No. of exotic shrubs	0	0	0	0	4

than on the Mornington Peninsula (Robinson *et al. in press*). A comparison of results between the two regions is, therefore, instructive.

Despite a complete absence of shared tree species between habitats used by the Grey-crowned Babbler on the Mornington Peninsula and in their stronghold on the Northern Plains, the environmental and structural attributes of the different habitats are surprisingly similar. As a result, the biology of birds in both districts is also similar.

In both districts, Grey-crowned Babblers are closely associated with grassy woodlands rather than with other vegetation types (Robinson *et al. in press*) and use the key foraging-habitat elements of those woodlands (grassy ground layer, trees) in similar proportions. More precisely, birds in each district are associated with woodlands growing on more fertile sites: in northern Victoria with woodlands occurring on the lower slopes or plains (Robinson *et al. in press*); and on the Mornington Peninsula with the woodlands of the Mooroduc Plains (see final section). Within these broad woodland categories, birds in each district show preferences for vegetation communities dominated by rough-barked and older trees: on the Mornington Peninsula by Manna Gum (rough-barked form), Coast Manna Gum, Drooping Sheoak and Black Sheoak; and on the Northern Plains by Grey Box *E. microcarpa*, Black Box *E. largiflorens* and Buloke *Allocasuarina luehmannii*

(Robinson *et al. in press*).

The preference for rough-barked and older trees is probably related, at least in part, to the Grey-crowned Babbler's specialised foraging behaviour. Babblers use their long, curved beaks to probe crevices in the bark, lever off bark or demolish rotting branches in search of invertebrates (Robinson *et al. in press*). Smooth-barked or young trees therefore provide less potential habitat for Grey-crowned Babblers than rough-barked trees or older trees do and are used rarely as foraging habitat in the Northern Plains (Robinson and Wildlife Branch 1992; Robinson *et al. in press*).

On the Mornington Peninsula, Grey-crowned Babblers likewise appeared to prefer sites with older and rough-barked trees. Indeed, so marked was the habitat selection of the Mornington Peninsula birds for rough-barked trees that babblers at Woodlands Golf Course foraged exclusively on the few surviving Coast Manna Gums and never on the more common but predominantly smooth-barked River Red Gums. Similarly, at those sites with few rough-barked trees, birds foraged mostly on rough-barked shrubs rather than on the trees on those rare occasions when they foraged above the ground (see 'foraging behaviour' section). By contrast, at the most natural site (Site 10), babblers mainly foraged in trees, particularly in larger trees, even though smaller trees and various species of shrubs were more abundant (Table 4). The loss of older trees from many sites and the consequent increase in

time spent on the ground thus may have contributed to the species' decline in the Mornington Peninsula region; perhaps by making ground-feeding individuals more vulnerable to attacks by cats *Felis catus*, a known predator of the species (Seabrook 1991), or perhaps by making it more difficult for birds to obtain enough food.

As found in Grey Box habitats in northern Victoria (Robinson *et al. in press*), babbler sites on the Mornington Peninsula typically included clumps of young trees or tall shrubs that were used by birds for nesting, shelter and shade. In both districts, Grey-crowned Babblers also preferred sites with low or scanty grasscover, presumably so that they could forage on the ground for food (Robinson *et al. in press*). In each district, then, the species' ideal habitat comprises a woodland of scattered trees and short grass, but always with some dense clumps of understorey vegetation which provide nesting sites and protection from predators and competitors.

Future of the Grey-crowned Babbler

On the Mornington Peninsula, this ideal habitat type of the Grey-crowned Babbler was closely associated with the lowland grassy woodland dominated by Snow Gum, Manna Gum and Narrow-leaved Peppermint on the Mooroduc Plains (Fig. 1). However, as has happened with all other lowland woodlands in temperate Australia (Lunt 1991; DCE 1992; Robinson and Traill 1996), the grassy woodlands of the Moorooduc Plains and other parts of the Mornington Peninsula were settled very early on by European squatters who considered the land ideal for grazing. A Government Surveyor's report on the Mornington Peninsula in 1841 thus illustrates all of the Moorooduc Plains as having been taken up by squatters, the environment being described variously as *'Open Forest Country good grass. Timbered with Gum, She Oak, Stringy Bark, light wood and wattle trees.'*, *'Good sheep feed. Open country timbered with Gum She Oak and light wood trees'*, and *'good soil and good grass lightly wooded with She Oak Gum and Cherry trees'* (Moorhead 1970). By 1856, 450 hectares of land on the Mornington Peninsula had been sown to crops and 1800 cattle roamed

the land. Fifteen years later, 1500 hectares had been sown to crops, and stock numbers had increased to 7200 head of cattle and 25,000 sheep (Peel 1974). In the same period, timber-cutters arrived and selectively cut down the sheoaks for timber and firewood to supply the burgeoning population of Melbourne (Moorhead 1970; Calder 1986), and a fruit-growing industry began in about 1860 (Moorhead 1970). By 1870, then, the lowland grassy woodlands of the Mornington Peninsula had been extensively modified by European settlers and it is likely that the Grey-crowned Babbler population endured its first major decline during this initial settlement period.

One hundred and thirty years later, the Mornington Peninsula's Manna Gum/Snow Gum woodland community has largely disappeared. Overall, just 14% of the Mornington Peninsula still retains tree cover (Fig. 2; Calder 1986). In the former Mornington, Hastings and Frankston Shires – wherein the woodland community was once widespread, or even dominant (from Calder 1986) – the area of remnant tree cover ranges between 6 and 10%. However, most of that remnant vegetation consists of heathy forest, coastal scrubs and stringybark/peppermint forest, not grassy woodland (Fig. 2; Calder 1986). If one considers just those intact remnants of Manna Gum/Snow Gum lowland woodland surviving on the plains, the largest surviving example (Mornington rail reserve) measures a total of ten hectares in size (from Yugovic 1993).

The demise of the Grey-crowned Babbler on the Mornington Peninsula thus
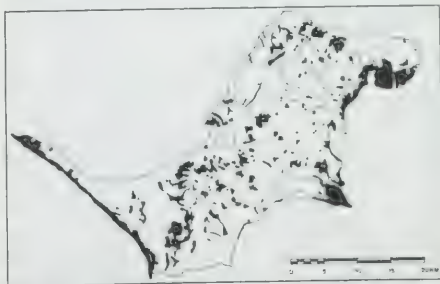
Fig. 2. The distribution of all remnant vegetation (shaded areas) on the Mornington Peninsula in 1985 and the historical distribution of Manna Gum/Snow Gum/Peppermint woodland (areas bounded by dashed lines). Data taken from Calder (1986).

conforms to the model of decline proposed more broadly for this species throughout Victoria (Robinson *et al. in press*). According to this model, initial clearing of most of the suitable habitat causes a major reduction in the size of the species' population and the fragmentation of the original population into a number of smaller populations or isolated groups. As a consequence of a range of subsequent, deleterious processes (e.g. continuing habitat loss, isolation from other groups and predation), the number of birds within every group decreases because of poor breeding success and lack of immigration. Eventually, family groups become too small to breed successfully and the remaining birds die. If this process continues unchecked, all of the groups within a district die out and the district's population becomes extinct (Fig. 3) (Robinson *et al. in press*).

On the Mornington Peninsula, the known Grey-crowned Babbler population consists of just six groups, has decreased by 65% in the past eight years and has not produced any young in the past two years. The population is further threatened by lack of suitable habitat, the extreme isolation of every group (Fig. 1), and increasing pressures from urban development, traffic, cats and other predators (Schulz 1991; Robinson *et al. in press*). Even if humans were now to intervene and relocate the birds so that they all lived close together and group size and breeding success might then increase, there is no area of potentially suitable habitat on the Mornington Peninsula which is large enough to support the remaining thirteen birds, let alone permit an increase in population size. It is therefore impossible to prevent the Grey-crowned Babbler from becoming extinct on the Mornington Peninsula within the next decade (Fig. 3). Importantly, however, some smaller species of woodland-dependent animals and plants (e.g. invertebrates and ground-layer plants) may be able to survive in the tiny remnants of grassy woodland that still persist along the rail reserves and road reserves on the Mornington Peninsula. Protection of such sites is crucial as a means of conserving some parts of the biodiversity once encountered in the Manna Gum/Snow Gum/Peppermint woodland community across the Peninsula's plains
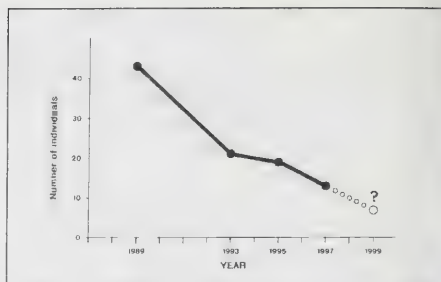
Fig. 3. The known decline and predicted future decline of the Grey-crowned Babbler population on the Mornington Peninsula.

(see Lunt 1993; Morgan 1993)

At present, neither the Mornington\ Frankston railway line nor identified roadside sites are managed wholly for conservation. Parts of the railway line are protected (I. Stevenson *pers. comm.*) but the line as a whole is managed for recreation (LCC 1994). The roadside sites have been identified as significant in the regional roadside plan (Context and Ecology Australia 1996) but are similarly vulnerable because of various roadside activities, degrading impacts from the adjoining land (e.g. weed invasion, nutrient runoff, water runoff) and edge effects (e.g. high rates of windthrow, increasd exposure, increased temperatures – see Saunders *et al.* 1991). We recommend that:

(1) the railway line be managed primarily for conservation;
(2) the grassy woodland sites along roadsides that have been identified as significant (see Context and Ecology Australia 1996) be signposted and delineated to protect them from roadside activities;
(3) landholders with properties adjoining the roadside sites be approached to fence out and revegetate contiguous strips of their land to act as buffers for the roadside sites;
(4) detailed surveys be done of the remnants' flora and invertebrate fauna to ascertain if there are woodland-dependent taxa;
(5) restoration programs be carried out, based on the results of those studies; and
(6) that an educational kit be prepared on the demise of the Grey-crowned Babbler and the implications for other species of woodland wildlife if nothing is done.

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Environmental Determinants of the Distribution of the Buffalo Sallee *Eucalyptus mitchelliana*

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and Peter Massingham*

*This publication is dedicated to Peter Massingham, whose enthusiasm
for the flora of Mt. Buffalo inspired us all.*

Abstract
The Buffalo Sallee is a willow-leaved snow gum that occurs only on Mt. Buffalo. The distribution
of the Buffalo Sallee is reported, as is a study of environmental parameters that may limit its range.
No substrate or climatic factors were identified that explain the limited range of this species. It is
possible that the Buffalo Sallee competes directly with snow gums, and that disturbance (especially
fire) has helped determine its present distribution. If this is true, fire control on the Mt. Buffalo
plateau may eventually lead to the decline of this rare snow gum.
(*The Victorian Naturalist* **114**, 1997, 278-281).

Introduction
Mount Buffalo is a granitic massif form-
ing a plateau that acts as an island habitat
containing several endemic species
(Costermans 1992). The endemics include
the Fern-leaf Baeckea *Baeckea crenatifolia*,
the Buffalo Sallow Wattle *Acacia phlebo-
phylla*, the Buffalo mint bush *Prostanthera
monticola* and a Snow Gum known as the
Buffalo Sallee, or *Eucalyptus mitchelliana*
(Cambage) (Fig. 1).

Only three populations of *E. mitchelliana*
are known, widely spread across the Mt.
Buffalo plateau, as shown in Fig. 2. The
plateau is divided into two main areas by
Buffalo Creek, with the less accessible
northern plateau having the largest popula-
tion (in terms of area) of *E. mitchelliana.*
The area surrounding the Gorge and Chalet
supports a well established population, as
does the Back Wall, south of the highest
point on Mt. Buffalo, known as The Horn
(1721 m). The Back Wall population dif-
fers from the other two in that the individu-
als retain scaly bark at the base of their
trunks and exhibit a mallee growth form
(multiple trunks), probably due to regrowth
from lignotubers (Chippendale and
Johnston 1983) following the fire of 1985.

Our study was designed to examine the
environmental parameters preferred by *E.
mitchelliana* in an effort to determine why
the distribution of this species is so limit-
ed. This task was simplified by the fact
that only four species of eucalypts occur

on the plateau: the common Snow Gum
E. pauciflora (Fig. 3), the Mountain Gum
E. dalrympleana, the Alpine Ash *E. dele-
gatensis*, and the endemic *E. mitchelliana*.

We chose three granitic outcrops of simi-
lar size as our study sites because they
provide a microcosm of the plateau with a
range of habitats over short distances. All
three sites represent a prominent rise on
the plateau covered with large boulders.
Two of these sites (The Monolith and

Fig. 1. The distinctive willow-like foliage of the
Buffalo Sallee. Photo Dean Heinze.

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* deceased 24 March, 1996.
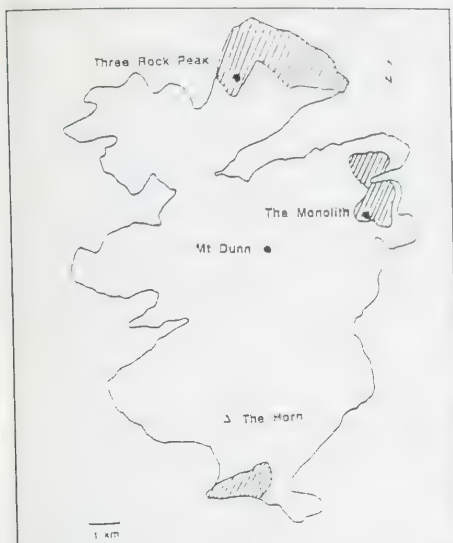
Fig. 2. The location of *Eucalyptus mitchelliana* populations (hatched areas) and the three study sites (dark circles). The outline of the figure corresponds to the 1200 m contour on the Mount Buffalo Plateau.

Fig. 3. *Eucalyptus pauciflora* on Buffalo Plateau. Photo Susan Lawler.

Three Rocks Peak) supported a population of *E. mitchelliana*, while one of them (Mount Dunn) did not (see Fig. 2). The sites also differed in altitude and the year in which the most recent fire was known to have burned the area (see Table 1).

On each granite outcrop we set up three transects. Because the topology of each outcrop differed, it was not possible to have all transects occur in exactly the same direction, due to the inaccessibility of one or more slopes. The aspect of the transects used is listed in Table 1.

For each transect the procedure was the same: beginning from the top of the out-crop, a tree was chosen randomly every 10 m following the direction of the transect until we reached the bottom (recognised by deep soil and the dominance of Alpine Ash). Trees were identified to species and we measured the circumference at breast height (later transformed to diameter at breast height), aspect of slope, altitude and soil depth. In addition a soil sample was taken at each tree which was later analysed for pH. Moisture content was determined at the time of pH analysis as being dry, moist or very moist based on whether the paper added to the sample for identification was dry, damp or obviously wet.

In all, a total of 105 trees were sampled.

Table 1. Description of study sites. Key: Alt - Altitude, Trans - Transects, *E.m.* - *Eucalyptus mitchelliana*, P - present, A - absent.

	Alt.	Trans.	Last fire	*E.m.*
The Monolith	1419 m	N, NW, SE	1939	P
Three Rocks Peak	1460 m	NW, E, SW	1972	P
Mount Dunn	1480 m	N, NE, SW	?	A

Results

Comparisons among the three study sites did not reveal any environmental cause for the absence of *E. mitchelliana* at Mount Dunn. The only significant environmental differences found were at Three Rocks Peak, where the pH was slightly higher and the average tree size was smaller (Table 2). The difference in tree size is almost certainly due to the more recent occurrence of fire in the area (Table 1). There may be some difference in soil types between the main and northern plateau, but this does not seem to influence *E. mitchelliana*.

Comparisons among the four species revealed a significant difference between *E. mitchelliana* and the others for soil depth and soil moisture (see Table 3). This

Table 2. Biotic and abiotic factors at each study site.
All values expressed as means with standard deviation in parentheses. Means that are significantly different are marked with an asterisk. Tree size was measured as the diameter at breast height in cm, soil moisture was determined for each sample with 1 = dry, 2 = moist, and 3 = very moist.
Key: M. - Monolith, M.D. - Mount Dunn, T.R.P. - Three Rocks Peak.

	M.	M.D.	T.R.P.
Soil depth (cm)	15.8 (6.9)	19.4 (6.6)	16.4 (7.2)
Soil pH	4.6 (0.5)	4.8 (0.6)	5.2 (0.4)*
Soil moisture	1.8 (0.8)	2.0 (0.8)	2.0 (0.8)
Tree size (dbh in cm)	39.0 (33.5)	34.2 (27.7)	18.3 (18.0)*

Table 3. Biotic and abiotic factors measured for each tree species. All values as in Table 2.
Key: *Em. - E. mitchelliana, Ep. - E. pauciflora, Eda. - E. dalrymrpleana, Ede. - E. delegatensis.*

	Em.	Ep.	Eda.	Ede.
Soil depth	13.1 (6.2)*	17.7 (6.9)	18.3 (8.2)	20.6 (5.6)
Soil pH	4.8 (0.5)	5.0 (0.6)	5.2 (0.7)	4.9 (0.6)
Soil moisture	1.3 (0.5)*	1.9 (0.7)	2.3 (0.8)	2.5 (0.7)
Tree size	20.99) (19.4	17.3 (13.6)	45.8 (36.6)	48.53) (33.3)

was due to the fact that the *E. mitchelliana* trees were invariably found at the top of the outcrops where the soils were shallow and dry. In addition, *E. mitchelliana* was more common on the northern aspects (72% of the *E. mitchelliana* counted vs. 46% of the *E. pauciflora*). In general, the two Snow Gums (*E. mitchelliana* and *E. pauciflora*) were smaller than the other eucalypts, as would be expected.

The prevailing distributional pattern at each site was consistent: if present, *E. mitchelliana* occurred at the summit, to be replaced by *E. pauciflora* at slightly lower altitudes. *E. dalrympleana* occurred at altitudes below the two Snow Gums, with *E. delegatensis* at the base of the outcrop in the deepest soils. Thus each site presented a microcosm of the environmental requirements of each species.

Discussion

Our analysis of the physical aspects of sites with and without Buffalo Sallee found no significant differences to account for the restricted distribution of the species. Since the observed range of *Eucalyptus mitchelliana* cannot be explained by substrate or climatic variations, we must look at other possible explanations for its restricted occurrence. These might include competition with other Eucalypts on the plateau, aspects of its evolutionary history that might determine present distribution, or the effect of disturbance, particularly fire.

Eucalyptus mitchelliana occurs in dry, shallow soils in exposed situations, often with a northerly aspect. Since the prevailing winds come from the northwest, these sites would have the harshest conditions on the plateau. Studies of another local endemic in NSW, *Eucalyptus paliformis,* showed that it was restricted to a unique habitat, yet the overriding factor in its distribution was competitive exclusion by a closely related species *E. fraxinoides* (Prober 1992).

The Snow Gum *E. pauciflora* is closely related to *E. mitchelliana*, and although both species occur within the distribution of *E. mitchelliana*, both species tend to occur in almost pure stands in any particular location. Unfortunately it is not known whether regeneration of these stands occurs primarily from seeds or regrowth from rootstock, although the population at the Back Wall appears to be a pure stand that has regrowth from lignotubers. Further study on the dispersal and regrowth of these two species would be of considerable interest in this context.

Eucalyptus mitchelliana has buds, fruits and leaves unlike the Snow Gum *E. pauciflora*, but similar to the Black Sallee, or *E. stellulata* (see Chippendale and Johnston 1983), which therefore may be its evolutionary progenitor. This species is not currently represented on Mount Buffalo, although the herbarium collection located at the Chalet (St. John 1938) indicates that *E. stellulata* was common in the vicinity of the Chalet as recently as the 1938. These specimens may have been used to build parts of the Chalet, or they may have been destroyed in the 1939 fire. Nevertheless, if the Buffalo Sallee were recently diverged,

it may have had inadequate time for dispersal, in which case the current distribution of *E. mitchelliana* could be partially explained by the former distribution of *E. stellulata* on the plateau. This explanation seems unlikely, however, because of the amount of time that is likely to have passed since the evolutionary divergence of the two species (although this is unknown), the lack of *E. stellulata* on the plateau, and the current distribution of *E. mitchelliana*, which is patchy but nevertheless widely spread across the plateau. Unfortunately we do not have data that will indicate whether the distribution of *E. mitchelliana* is currently expanding or shrinking.

The three known populations of Buffalo Sallee share the attributes of rocky exposed sites at the edge of the Mount Buffalo plateau. The one location used for this study which does not support a population of *E. mitchelliana* (Mount Dunn), nevertheless seems perfectly suitable for the species. The important difference may be the fact that the area surrounding Mount Dunn is one of the few areas on the plateau that has not been disturbed by fire in recent history (Dexter *et al.* 1977; Mount Buffalo Rangers *pers.comm.*).

Disturbance may be required for the Buffalo Sallee to become established. This interpretation is supported by the fact that all of the current populations of *E. mitchelliana* occur in areas known to be affected by fire in the recent past. The area around the Chalet was burnt in 1939, Three Rock Peak was burnt in 1972, and the population at the Back Wall was burnt in 1985 and consists of an almost pure stand of *E. mitchelliana*. The location of all populations along the edge of the plateau could be explained by the fact that local updrafts along steep escarpments are ideal places for fire to enter the plateau. Mt. Dunn was not burnt in any of these fires, making it one of the least disturbed sites on the plateau. There remain many portions of the plateau, however, that have been burnt recently yet do not have a population of *E. mitchelliana*, raising questions about the dispersal mechanisms of the species. Certainly fires have been common on the plateau in the past, including fires set by

people to improve grazing pasture prior to 1958 (Dexter *et al.* 1977).

Young specimens of *E. mitchelliana* can be seen along roads and tracks, but are not found in undisturbed areas. If competition with *E. pauciflora* limits the distribution of this species, it may be that disturbance provides it with the opportunity to become established. If this is the case, management plans designed to reduce the possibility of fires on the plateau (DCE 1992) may need to be reconsidered.

In summary, *E. mitchelliana* occurs in thin, dry soil in exposed sites and may require disturbance or fire in order to become established. Both of these conditions could be due to intense competition with the more common *E. pauciflora* on the plateau.

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Drooping Sheoke *Casuarina verticillata* in the Mallee

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Abstract
    This paper describes a unique occurrence of Drooping Sheoke *Casuarina verticillata* on deep sands in Wyperfeld National Park in the Mallee Region of Victoria. (*The Victorian Naturalist* 114, 1997, 282-284).

Introduction

Three small shrubby species of *Casuarina* (in the broad sense), rarely reaching over 2 m tall, are found in the deep, infertile sands of the Big Desert heathlands – i.e. Slaty Sheoke *Casuarina muelleriana*[a], Dwarf Sheoke *C. pusilla* and Coarse Sheoke *Casuarina* species. *Casuarina muelleriana* is also found on taller sand dunes under shrubby mallee eucalypts throughout much of the region. Bulokes *C. luehmannii*[b] are common trees in the mallee regions of north-west Victoria and less common but still widespread in south-western New South Wales, principally in areas receiving between 300–550 mm mean annual rainfall (Sluiter and Parsons 1995). They are restricted to the heavier, more fertile, reddish loams and do not occur on the deep sands that characterize most of the region, although there is a tendency for them to be restricted to lighter soils at the more inland occurrences (least rainfall). Belah trees *C. pauper* are common on red, sandy loams in the northern Mallee, extending to inland Queensland and South Australia, generally in areas receiving from 175–275 mm mean annual rainfall (Sluiter and Parsons 1995). *Casuarina pauper* and *C. luehmannii* are often sympatric but only very rarely occur as a mixed stand (e.g. at the Walpeup Agricultural Research Station). Even when occurring in the same small woodland block they almost invariably segregate, with *C. pauper* usually occupying the higher or more topographically-arid sites. The endangered *C. obesa* is restricted to a remnant stand near Mildura in north-western Victoria, plus a few lakesides in the Wimmera. *Casuarina obesa* is apparently extinct in New South Wales (where it formerly occurred on the shoreline at Lake Benanee, near Euston).

A single Drooping Sheoke *C. verticillata*[c] Lam. on the very top of Flagstaff Hill (a deep sand dune, immediately north of Wonga Campground in Wyperfeld National Park, Victoria) was the only Mallee record of this otherwise common tree. Until the early 1980s, *C. verticillata* was not known from any other locality in the Mallee. Apart from coastal occurrences, its habitat elsewhere in south-eastern Australia does not include deep, aeolian, siliceous sands (Fig. 1). The single tree on Flagstaff Hill is clearly older than the declaration of much of Wyperfeld National Park, nevertheless, it has even been suggested that it derived from deliberate planting, rather than a 'natural' occurrence. This tree has subsequently died - though the stump is still visible.

Following the first Land Conservation Council study of the Mallee region in Victoria (LCC 1974) a substantial area of land was recommended for addition to Wyperfeld National Park. As much of this land had been grazed for many years, an inspection and report on the conservation values was made. During one of these inspections (in October 1983) a small population of *C. verticillata* was found. This population was reassessed in 1995.
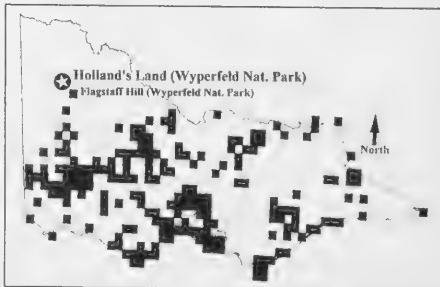
Fig. 1. Distribution of *Casuarina verticillata* in Victoria, based on 10' grid records. Map supplied by Flora Section, Department of Natural Resources & the Environment.

[1] Parks and Wildlife Commission of the Northern Territory, PO Box 496, Palmerston, Northern Territory 0831.

Fig. 2. Mature *Casuarina verticillata* at Holland's Land, Wyperfeld National Park, October 1983.

1983 Inspection

In October 1983 a small stand of *C. verticillata* was discovered on the high sand dune immediately north of the far southern boundary of the block known as 'Holland's Land' (crown allotment 40, Parish of Baring; Fig. 2). This stand comprised 8 individuals of various sizes (and, presumably, ages) and both sexes, and was restricted to the top of the tallest dune, which was composed solely of deep, siliceous sand. Altho this dune was particularly tall, it showed no evidence of having been burnt (it was the tallest dune in the immediate vicinity - there was a clear view south to Flagstaff Hill, which was also notably higher than the surrounding dunes and lunettes). The widespread wildfires of 1946 and 1959 had not reached this long-unburnt stand of mallee eucalypts. The smaller *C. verticillata* present presumably germinated and established in the absence of fire.

1995 Inspection

On 30 October 1995 the *C. verticillata* stand was relocated. It was still restricted to the top of this particularly tall dune, but

Table 1. Other vascular plants[a] recorded from the *C. verticillata* stand.
Cover-abundance estimates are: 2 - Plants common, 5% - 20% projective canopy cover; 1 - Plants common, < 5% projective canopy cover; + - Plants uncommon, <5% projective canopy cover; r - Plants sporadic (less than 2 individuals in the quadrat), <5% projective canopy cover.

Tall shrubs	
2 *Acacia calamifolia*	1 *Brachyscome lineariloba*
2 *Acacia ligulata*	1 *Crassula sieberiana*
2 *Eucalyptus costata*	1 *Millotia tenuifolia*
1 *Callitris verrucosa*	1 *Podolepis capillaris*
Low Shrubs	1 *Podotheca angustifolia*
2 *Beyeria lechenaultii*	1 *Silene gallica* *
+ *Halgania cyanea*	1 *Wahlenbergia gracilenta*
+ *Lasiopetalum behrii*	
r *Bertya mitchellii*	+ *Avellinia michelii* *
Perennial Herbs	+ *Brassica tournefortii* *
2 *Glischrocaryon behrii*	+ *Calandrinia eremaea*
	+ *Daucus glochidiatus*
1 *Clematis microphylla*	+ *Euchiton* sp. (annual)
1 *Danthonia caespitosa*	+ *Isolepis marginata*
	+ *Millotia muelleri*
1 *Thysanotus patersonii*	+ *Pachymitus cardaminoides*
+ *Calotis erinacea*	+ *Pelargonium australe*
+ *Helichrysum leucopsideum*	+ *Sonchus oleraceus* *
+ *Oxalis perennans*	+ *Trachymene pilosa*
+ *Senecio lautus*	+ *Vulpia bromoides* *
+ *Stipa hemipogon*	r *Arctotheca calendula* *
Annual Herbs	r *Bromus rubens* *
2 *Calandrinia granulifera*	r *Hypochoeris glabra* *
2 *Millotia myosotidifolia*	r *Pentaschistis airoides* *

now consisted of 42 individuals. Two of these were vegetative regeneration after the recent fire (1984/1985 fire season) (Fig. 3). The other forty were seedling regenerants, and they have reached 2–3 m tall. Some of the larger seedling regenerants had mature 'cones' (i.e. a seed reserve was already re-established). The fire appeared to have killed the largest and smallest sheokes from the pre-fire stand.

A 20x20 m quadrat was placed around most of the sheoke population and all vascular plant species occurring within the quadrat were recorded and assigned a cover-abundance estimate (Table 1). Introduced species are indicated by an asterisk after their names.

Conclusion

The vegetation community is Deep-sand Mallee (Cheal and Parkes 1989). The species richness is somewhat higher than

Fig. 3. *Casuarina verticillata* at Holland's Land, Wyperfeld National Park. October 1995. This specimen regenerated by resprouting after the 1984/1985 fire.

usual, but not remarkably so. Apart from the *C. verticillata* itself, none of the species is unusual in this vegetation community. Nor is the vegetation notably more or less weedy than is usual for Deep-sand Mallee. This is *not* a 'relict' habitat supporting a stand of vegetation otherwise unusual in the region. It is a typical stand of Deep-sand Mallee that happens to include one species (i.e. *C. verticillata*) not normally present in this vegetation community and not normally present in the region.

The reasons for the persistence and vigour of *C. verticillata* at this site are unknown. Apart from its elevation above the surrounding dunes, there does not appear to be anything particularly unusual or remarkable about this site.

Casuarina verticillata in Wyperfeld successfully occupies, and regenerates in, habitat that is far from typical for the species **nowadays**. This single, vigorous stand indicates a considerably broader ecological amplitude for this *Casuarina* species than was formerly thought to be the

case. It highlights the need for care in interpreting former vegetation patterns from the current distributions and abundances of species and the vegetation communities they **currently** constitute, particularly given the supposed critical place of *Casuarina* as a regional dominant in much of inland south-eastern Australia in the Pleistocene and Holocene (Thomas and Kirkpatrick 1996; Truswell 1993).

[a] Nomenclature follows Hwang (1992). These low shrubs are also known as *Allocasuarina pusilla*, *Allocasuarina muelleriana* and *Allocasuarina mackliniana* respectively, see Johnson (1982).
[b] Nomenclature follows Hwang (1992). This tree is also known as *Allocasuarina luehmannii*, see Johnson (1982).
[c] Nomenclature follows Hwang (1992). This tree is also known as *Allocasuarina verticillata*, see Johnson (1982),and was formerly known as *Casuarina stricta*.
[d] Except for *Casuarina* spp, vascular plant nomenclature follows (Walsh 1994, 1996; Ross 1993).

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Southern Boobook Foraging Amongst Foliage

John M. Peter[1]

The Southern Boobook *Ninox novaeseelandiae* is widespread throughout most parts of Australia and New Zealand. Within this range, it occurs in virtually all habitats which support at least a few trees, ranging from open woodland and partly-cleared farmland to tropical rainforest (Blakers *et al.* 1985; Bull *et al.* 1985; Hollands 1991; Higgins *in press*). Its diet consists mostly of invertebrates, primarily insects and spiders, though frogs, lizards, birds and small mammals are sometimes also included (Lea and Gray 1934; Barker and Vestjens [*undated*]; Hollands 1991; Higgins *in press*). When foraging, Boobooks usually search for prey while perched on a prominent, elevated feature, often a branch, but sometimes a post or some other artificial structure. When suitable aerial prey is located, the Boobook pursues it in flight, returning to the perch to eat it. Terrestrial prey is caught by gliding from the perch to the ground (Schodde and Mason 1980; Higgins *in press*). There are surprisingly few published records of Southern Boobooks foraging for arboreal prey.

On 13 January 1996, while spotlighting near Torquay, Victoria, in a remnant patch of low open Messmate *Eucalyptus obliqua* forest surrounded by open pasture, I observed a party of four Southern Boobooks, possibly a family group, in a tree. Two of the owls continually left their perch, flying erratically after insects, which they only consumed after returning to their branch. After several successful sallies in pursuit of flying insects, one of the Boobooks flew from its perch directly towards a clump of foliage in the outer canopy of a nearby tree. When it was within a few centimetres of the outer leaves, the owl began to hover, vigorously fluttering its wings so that they beat against the foliage several times. As the bird's flapping wings struck the foliage, numerous insects, thought to have been beetles, were displaced. The owl then caught one of these insects in mid-air and ate it after flying back to its perch. Similar foraging behaviour has also been observed in Tasmania (Ralph 1994).

As well, in New Zealand, a Boobook was seen fluttering 'like a moth round a lamp' among the dense foliage of a tree, in an attempt to flush a House Sparrow *Passer domesticus* which was roosting there (Sibson 1989). However, possibly, a more usual method employed by Southern Boobooks, when foraging among foliage in trees or shrubs, is to crash into the canopy to seize prey, such as insects or roosting birds, from among the leaves (Pizzey 1958; Sharland 1958; Hollands 1991; Debus 1996). This is a tactic more commonly used by some larger owls, such as the Rufous Owl *Ninox rufa*, which mostly forage in the canopy (Hollands 1991).

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Back To Lankey's Plain

R.J. Fletcher[1]

During 1996 the author came across a copy of the Victorian National Parks Association magazine 'Parkwatch' dated Winter 1984. Part of the contents consisted of an article by Jean Galbraith entitled 'Lankey's Plain - a floral regression'. Lankey's Plain has for some years been a place visited by the author and holds a special interest because it was where he made his first acquaintance with the Alpine Marsh-marigold *Caltha introloba* and Golden Moths *Diuris lanceolata* (Fig. 1).

Lankey's Plain is about 50 km from Dargo on the Mt. Hotham Road, several kilometres north-west from the Treasure family freehold property. It lies at an altitude of approximately 1500 m and is therefore classified as a subalpine habitat. It is part of the Alpine National Park (Fig. 2).

Jean Galbraith's article covered two visits, the first in January 1969 and the second in January 1980, so it was planned to make a visit at the same time of the year, in January 1997. In the event the actual time of the visit was the last four days of December 1996. Jean Galbraith's concern, as has been the concern of many others before and since her trips, was the deterioration of the variety of the flora because of continued summer cattle-grazing over many years. Although Lankey's Plain is within the boundary of the Alpine National Park, it is still the subject of a grazing permit at intervals of seven years. The permit allows grazing from early December until late March each year.

Table 1 lists the species noted by Galbraith in both 1969 and 1980. Those identified in 1996 are marked with a plus (+) sign. Of particular interest was her comment that just at the entrance to the Plain there were two fenced areas, containing the additional list observed in 1980. There were no signs of such areas in his 1996 visit, although there is a zone at the eastern end of the Plain excluded from the grazing permit. This zone is securely fenced and is the subject of surveys from time to time. However, on this visit it appeared to contain none of the showy

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plants listed during January 1980. One looked in vain for a show of Orange Everlasting *Bracteantha subundulatum* or either of the *Podolepis* species on the list. The only species on that list making anything of a show was Common Billy-buttons *Craspedia glauca*. There were also a few of the various alpine daisies and an excellent specimen of Swan Greenhood *Pterostylis cycnocephala* (Fig. 3). This particular species was also seen on the open Plain.

Many of the characteristics of Lankey's Plain have not changed much over the years. The stream still crosses through the bog area from east to west, and the higher ground is still rocky and occupied by *Eucalyptus pauciflora* with an understorey of *Poa* spp., Mountain Pepper *Tasmannia xerophylla* and Shaggy Bush-pea *Oxylobium alpestre*. There were many variations in the plant species observed when compared with Jean Galbraith's lists. One can't be sure how comprehensive her surveys were, and she has difficulty in recalling the detail after so many years.

The survey made during the 1996 visit is
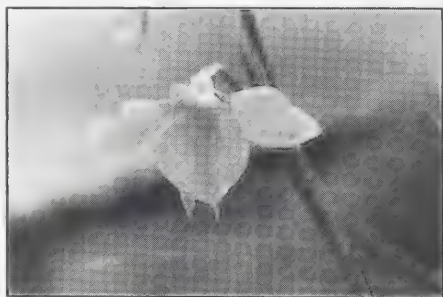
Fig. 1. Golden Moths *Diuris lanceolata*.

Fig. 2. Lankey's Plain, looking north.

Fig. 3. Swan Orchid *Pterostylis cycnocephala.*

not complete, but revealed an excellent list of surviving plants, so all is not lost. The lists made during the last days of 1996 are shown in Table 2 and Table 3. It needs to be said that the visit made at this time covered a period of nearly four days and that the plant survey left many species unidentified because of lack of expertise.

Jean Galbraith commented that in 1980 there was no visible fragment of sphagnum along the stream. This can no longer be said to be so, as in several areas there are quite extensive patches of Sphagnum Moss *Sphagnum cristatum* with good stands of Candle Heath *Richea continentis* and Snow Daisy *Brachyscome nivalis*. Certainly there are many degraded areas, destroyed by cattle and polluted with their dung. The latter also makes it rather difficult to find a clean camping spot since the clear areas among the Snowgums have all been used by cattle as their camping areas.

There were several surprises among the plants seen. Jean Galbraith remarked that, apart from a few plants in narrow rock crevices where cattle could not reach, there were no plants of the Snow Aciphyll *Aciphylla glacialis* to be seen. While not plentiful, quite a few plants were noted on the open Plain which would perhaps indicate that the area is not being over-

grazed. One wonders what the result would be if the area were not grazed at all. Three *Epilobium* species were recognised, although there was no way of distinguishing whether a fourth, Carpet Willow-herb *E. willisii* was among them, because one would need ripe seed to distinguish it from Bald-seeded Willow-Herb *E. curtisiae.* The other willow herbs noted, although not in any great numbers, were Robust Willow-herb *E. billardierianum* and Gunn's Willow-herb *E. gunnianum.*

Not mentioned by Galbraith was a stand of Mountain Plum Pine *Podocarpus lawrencei.* This was found in a prostrate mass over rocks right in the middle of one arm of the Plain, and growing alongside was another mass, also prostrate, of Tree Violet *Hymenanthera dentata,* which was also growing as a shrub among the Snowgums, and apparently untouched by the cattle. At least four species of *Ranunculus* were noted but because the achenes were not yet mature perhaps it is better to err on the side of caution concerning identification. However, there appeared to be no doubt concerning the mats of Bog Buttercup *R. pimpinellifolius* common on boggy sites.

Among mats of *Viola* species were also colonies of Sky Lily *Herpolirion novae-zeelandiae,* and plants of Alpine Marsh-marigold *Caltha introloba* were common near the streams, especially near the mats of Sphagnum Moss. The rather startling presence of the Starfish Fungus *Aseroe rubra* (see front cover) glowing red and black, was observed on two occasions, looking like something from 'out there' among the clumps of Snow Grass.

There is, of course, a down side to all of this. Jean Galbraith asked the question when she saw part of the Plain in all its glory, whether or not the whole area had once been like that. This is a question that cannot be answered. The accompanying tables indicate only three introduced species but of course there are far more than that. There are several species of Clover and many more species of Grasses than are listed. There are probably many more introduced weeds but more time and knowledge would be needed to identify them all. There is also the problem of dung, both on the Plain and in the understorey of the wooded areas surounding it.

However, it must also be said that in spite

of the gloomy outlook in 1969 and 1980, even a partial survey of Lankey's Plain is a very rewarding experience. It may be some time before cattle grazing in such areas of the National Park ceases, but in the meantime it is good to know that there is still something left for the future and, hopefully, the basis for a good recovery.

Acknowledgements

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Fig. 4. Alpine Leek Orchid *Prasophyllum tadgellianum*

Table 1. Species noted by Galbraith (1984).

1969

Moss, Sphagnum	*Sphagnum cristatum* +
Grass, Snow	*Poa* sp. +
Bluebell, Fairy	*Wahlenbergia densifolia*
Bluebell, Royal	*W. gloriosa*
Bluebell, Tall	*W. stricta* +
Buttercup, Dwarf	*Ranunculus millanii*
Coprosma, Snow	*Coprosma nivalis*
Cotula, Alpine	*Cotula stricta* +
Violet, Tiny	*Viola sieberiana* +
Willow-herb, Carpet	*Epilobium willisii*
Willow-herb, Bald-seeded	*E.curtisiae* +

1980

Grass, Snow	*Poa* sp. +
Bluebell, Fairy	*Wahlenbergia densifolia*
Bluebell, Royal	*R. gloriosa*
Buttercup, Bog	*Ranunculus pimpinellifolius* +
Buttercup, Granite	*R. graniticola* +
Coprosma, Snow	*Coprosma nivalis*
Daisy, Silver	*Celmisia astelifolia* + = *C.* sp.
Marsh-marigold, Alpine	*Caltha introloba* +
Willow-herb, Bald-seeded	*Epilobium curtisiae* +
Woodruff, Mountain	*Asperulia gunnii*

In fenced areas at the entrance:

Bluebell, Tall	*Wahlenbergia stricta*
Billy-buttons, Common	*Craspedia glauca*+
Everlasting, Orange	*Helichrysum acuminatum* = *Bracteantha subundulatum*
Podolepis, Showy	*Podolepis jaceoides*
Podolepis, Alpine	*P. robusta*
Sunray, Chamomile	*Helipterum anthemoides* = *Rhodanthe anthemoides*

Table 2. Species found in 1996.

Fungi:

Fungus, Starfish	*Aseroe rubra*

Moss

Moss, Bog	*Sphagnum cristatum*

Monocotyledons

Caladenia, Mountain	*Caladenia lyallii*
Grass, Timothy	*Phleum pratense*
Greenhood, Swan	*Pterostylis cycnocephala*
Leek-orchid, Alpine	*Prasophyllum tadgellianum* (Fig. 4)
Lily, Sky	*Herpolirion novae-zeelandiae*
Moths, Golden	*Diuris lanceolata*
Plum-pine, Mountain	*Podocarpus lawrencei*
Sedge	*Carex blakei*
Snow-grass, Bog	*Poa costiniana*
Woodrush	*Luzula alpestris*

Table 3. Species found in 1996.

Dicotyledons			
Aciphyll, Snow	*Aciphylla glacialis*	Grevillea, Alpine	*Grevillea australis*
Billy-buttons, Common	*Craspedia glauca*	Hakea, Small-fruit	*Hakea microcarpa*
Bluebell, Tall	*Wahlenbergia stricta*	Heath, Candle	*Richea continentis*
Bottlebrush, Alpine	*Callistemon sieberi*	Heath, Coral	*Epacris microphylla*
Bush, Daisy	*O. algida*	Heath, Swamp	*E. paludosa*
Bush-pea, Shaggy	*Oxylobium alpestre*	Marsh-marigold, Alpine	*Caltha introloba*
Bush-pea, Rough	*Pultenaea scabra*	Pansy, Wild	**Viola tricolor*
Buttercup, Bog	*Ranunculus pimpinellifolius*	Pepper, Mountain	*Tasmannia xerophila*
		Plantain	*Plantago euryphylla*
Buttercup, Granite	*R.. graniticola*	Ranunculus	*R. eichlerianus*
Buttercup, Strawberry	*R. collinus*	Rice-flower, Tall	*Pimelea ligustrina*
Carraway, Australian	*Oreomyrrhis eriopoda*	Rusty-pods	*Hovea montana*
		Trigger-plant, Grass	*Stylidium graminifolium*
Clover	**Trifolium spp.*	Violet, Ivy-leaf	*V.hederacea*
Cotula, Alpine	*Cotula alpina*	Violet, Showy	*V. betonicifolia*
Cranesbill	*Geranium potentilloides*	Violet, Tiny	*V.sieberiana*
		Violet, Tree	*Hymenanthera dentata*
Cress, Bitter	*Cardamine astoniae*		
Daisy-bush, Dusty	*Olearia phlogopappa*		
Daisy, Snow	*Brachyscome nivalis*	Willow-herb, Bald-seeded	*Epilobium curtisiae*
Daisy, Silky	*Celmisia sericophylla*	Willow-herb, Gunn's	*E.gunnianum*
Daisy, Silver	*C. spp.*	Willow-herb, Robust	*E. billardierianum*
Fanflower, Creeping	*Scaevola hookeri*		
Flax, Native	*Linum marginale*		

Filling the Blanks in Fungal Distribution

Ron Fletcher (see article above and front cover) records from Lankey's Plain the distinctive stinkhorn fungus *Aseroe rubra*. Despite its bizarre appearance, detailed distributional and ecological data for the species is yet to be compiled. Indeed, such data are lacking for most Australian fungi. The Australian fungal mapping scheme (FUNGIMAP) aims to fill in the blanks in our knowledge of the distribution and ecology of Australian fungi. The scheme is presently focussing on the distribution of 50 target species, one of which is *Aseroe*.

So far, more than 70 records of *Aseroe* have been received, providing a good indication of distribution, preferred habitat and the time of occurrence. In south-eastern Australia the species has a natural distribution in the high country (in localities such as the Bogong High Plains, Lake Mountain and Kosciusko National Park), at altitudes as high as 1,800 m, and mainly appearing in summer. Yet in Tasmania, *Aseroe* seems quite at home in temperate rainforest at lower altitudes. There are also sightings from urban areas at low altitudes, where the fungus is often associated with mulch or wood chips.

Piecing together the distribution of *Aseroe* from Tasmania to Queensland requires more records. If you are interested in taking part in the scheme by looking out for *Aseroe* and the other target species, please write to FUNGIMAP at the address below.

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Insect Galls on Plants

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Abstract
The variety of gall-forming insects in Australia is outlined, and examples of insect galls illustrated. The major insect groups involved are thrips, coccids, wasps and flies. The ecology of gall-forming is briefly discussed. Many gall insects are plant specific, and the galls have very characteristic forms. Galls can form the basis for complex ecological communities, and can be invaded by other insects after they have become established. (*The Victorian Naturalist* 114, 1997, 290-295).

Introduction

The intricacies of insect-plant interactions are perhaps nowhere more intriguing than amongst those which manifest as galls. Although only about 2% of plant-feeding insects cause galls (Dreger-Jauffret and Shorthouse 1992), the relationships are usually highly specific, a variety of different groups of insects are involved, and the gall-forming habit has arisen in insects 'many times and in many different ways' (Gagne 1984).

There is no general all-embracing definition of the term 'gall', despite considerable advances in cecidology (the study of galls) and the importance of galls in both scientific and applied contexts. In general, a gall is a deformation or enhanced development of the plant, usually involving production of additional tissue as atypical growth (either of a highly specific form or a simple proliferation of more generalised tissue, parenchyma) caused by an external agent and providing an environment in which that agent can live and develop. Most such agents are restricted to particular species and parts of plants, cause galls of a characteristic form by which they can be recognised or diagnosed, and sustain benefit from them. But more rigorous definitions may exclude examples which are classically considered to be galls (Williams 1994). People have long been fascinated by galls (about 60 different kinds were described by Malpighi in 1687 in 'Opera omnia de gallis', generally considered to be the foundation of gall studies), and the more conspicuous structures have a long history of involvement in a number of areas: in superstition and folk medicine; as model systems for physiological studies; as

'island habitats' which can form the basis for complex communities of organisms, and in applied fields such as the biological control of weeds (Harris and Shorthouse 1996). Descriptive terms for gall classification have tended to mirror their appearance (pouch galls, blister galls, apple galls, etc.), position (leaf galls, stem galls) and complexity (whether simple in structure or highly elaborated, whether hosting one or many inhabitants).

The gall-forming habit

There seem to be two major routes through which insects have become gall-formers, essentially either from inside the plant as by leaf-mining or by entering the plant from outside. In addition to gall-forming, other forms of endophytic ('inside plant') existence include boring and mining in plants, and such feeding by some insects (such as some Lepidoptera, for example the gracillariid moth *Epicephala* on *Acacia longifolia* around Melbourne: New 1981) induces formation of callus tissue in their mines. Indeed, the distinction between mines and galls is not always clear (Hering 1951), and may depend simply on whether such additional tissue is produced. Proliferation of callus, and its organisation in specific form, is one major way in which galls are formed. The other route, exhibited by some psyllid bugs, aphids and thrips, is a transition from sedentary surface-feeding, through formation of feeding 'pits' caused by differential plant growth, to enclosure in galls. For either route to succeed, initiation of swelling in plant tissues should rapidly benefit insect feeders to foster directional selection in favour of larger plant galls (Price *et al.* 1987).

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Adaptive nature of galls

Most commentators have presumed that galls are adaptive (that is, they provide benefit to one or other partner in the association, or to both parties), with the spectrum of opinion ranging from their being non-adaptive, through protection of the plant by localising and focussing insect attack, mutual benefit to plant and insect, to varied benefits to the causative agent. These putative benefits include improved nutrition, optimal or protective microenvironments, and protection against attack by predators and parasitoids (Price *et al.* 1987). These arguments are difficult to test critically, but there is little current support for either the 'non-adaptive' or 'mutualistic' hypotheses. The balance of opinion and evidence favours the 'benefits to causative agent' approach and, as many gall-formers are attacked heavily by parasitoids (indeed, they have 'some of the richest faunas of natural insect enemies known to attack insects': Price *et al.* 1987), the clearest benefits may relate to nutrition and environmental buffering. In essence, galls isolate the insect in time and space (Mani 1964), so that it depends wholly on that restricted environment for its wellbeing. The two main benefits, therefore, may be:

(a) Nutritive benefit. Insects modify the plant resources available to them by inducing galls. Galls provide sites for concentration of nutrients, and thus constitute sites which provide greater nutritive and energy rewards than unmodified tissue. They are, in essence, 'sinks' for nutrients from adjacent regions of the plant, and some insects feed in ways which enhance this nutritional enrichment - such as by severing the vascular tissue to prolong the persistence and quality of the galls through nutrition provided by the callus tissue. Harris and Shorthouse (1996) demonstrated the clear value of such species as biological control agents against weeds, because nutrient sinks 'capture' energy potentially available for other plant growth and reproduction; in consequence, the plant may be weakened severely.

(b) Environmental benefit. The notion that galls provide shelter and protection from harsh environments is widespread, but few hard data have been accumulated to endorse this. However, it is probably significant that some of the most diverse gall faunas occur in arid or semiarid regions. In North America, for example, there is massive contrast between the high diversity of galls in the Sonora Desert and the lower diversity in wetter areas of Arizona, suggesting strongly that galling is correlated with dry sites, and possibly implicating hygrothermal stress as a selection factor for this (Price *et al.* 1987).

Gall-forming agents

As well as other animals such as rotifers, nematodes and mites, and a wide range of viruses, bacteria, fungi and plants, many kinds of insects induce galls on plants. Globally, the major groups of insects involved include representatives of Thysanoptera (thrips), Hemiptera (sucking bugs, particularly coccids and lerp insects), Diptera (flies, particularly the gall midges), Hymenoptera (wasps), Lepidoptera (moths) and Coleoptera (beetles). Some groups in each of these orders have adopted galling as their predominant way of life (Mani 1964).

Galls can occur on any part of a plant, but are most diverse on foliage (around 70% of the total) and stems. They are also most diverse on angiosperms (Mani's, 1964, figure of 98% of known galling species frequenting flowering plants has not been changed dramatically), with small numbers on conifers and, despite lack of comprehensive surveys, apparently even fewer on lower plants.

Table 1. Groups of gall-forming insects in Australia.

Order	Lower taxa
Thysanoptera	Phlaeothripidae (several genera)
Hemiptera	Coccoidea
	Eriococcidae
	Asterolecaniidae
	Diaspididae
	Psylloidea
	Triozidae
Hymenoptera	Chalcidoidea
	Pteromalidae
	Torymidae
	Eurytomidae
	Eulophidae
	Agaonidae
Diptera	Fergusoninidae
	Cecidomyiidae
Coleoptera	(various, few)
Lepidoptera	(various, few)

Australian gall-forming insects

Major gall-forming groups in Australia are listed in Table 1. Knowledge of these is uneven, and perhaps only for some Thysanoptera, Hemiptera: Coccoidea, Hymenoptera: Pteromalidae and, to a lesser extent, Diptera: Fergusoninidae, has more than a scanty suite of biological information been accumulated. Some of these groups demonstrate remarkable features of the Australian insect fauna, many manifesting the diverse developments of insects that have occurred on *Eucalyptus* or *Acacia* (New 1988), and which are now notable endemic or near-endemic radiations. The following examples emphasise these hosts, but many other plants are also involved. A useful, illustrated summary of some gallformers on Australian plants is provided by Jones and Elliot (1989). Examples of the galls are shown in Figs 1-8.

Thysanoptera.

The gall-forming Phlaeothripidae on Australian *Acacia* (phyllode galls) and *Casuarina* (woody stem galls) have received considerable recent attention (Mound 1994; Crespi 1992; Mound and Crespi 1992), and have revealed fascinating degrees of aggressive fighting between these insects. Females of *Kladothrips rugosus* defend gall sites on Myall, *Acacia pendula*, by killing other females, and males, likewise, fight to the death to leave a single survivor. The pouch galls of this and other taxa (such as *Oncothrips, Onychothrips*) on *Acacia* phyllodes arise from a small surface depression induced by a feeding individual. The depression deepens rapidly, and its lips close over the thrips to form enclosed chambers in which the insects and their progeny are sealed (Mound 1971,1994).

Woody galls are infrequent for Thysanoptera. The *Casuarina*-galling taxa comprise three closely related genera (each with a single species) which sometimes occur together on the same plants (Mound and Crespi 1992), and populations can reach several thousand individuals. The mode of gall induction has not been clarified, and, as with the *Acacia*-galling species, enlarged forelegs are used in extensive fighting between individuals.

Hemiptera. The most spectacular insect galls in Australia occur among the Coccoidea, in which the abundance of gall-forming taxa renders our fauna unique (Beardsley 1984; Gullan 1984). The largest genus, *Apiomorpha*, produces large, often sexually dimorphic, woody galls on *Eucalyptus*. Female galls can be 5 cm or more in length on stems (those of *A. duplex* can reach 15 cm or more, including the 'horns'), whereas male galls are smaller (to about 1 cm long) and usually on foliage. Nearly 40 species are recognised (Gullan 1984), and many can be diagnosed on the unique shape of the gall. The wingless, juvenile-like females live in a large smooth-walled chamber in the gall. Some species of *Apiomorpha* have many hosts. Others are known from only one or two species, but the genus is confined to eucalypts. Other Australian Eriococcidae which form galls on *Eucalyptus* are *Opisthoscelis* (ca 15 species, some commonly found in groups) and *Ascelis* (ca 5 species), and examples of these are illustrated by Froggatt (1921). Yet others, such as *Cylindrococcus*, occur on *Casuarina*.

Within the Psylloidea, some Psyllidae: Spondyliaspinae form shallow pit galls on eucalypt foliage, and others produce larger more enclosing galls; in both types the gall is covered by a conventional lerp. The related family Triozidae are poorly known in Australia, but some species cause distortions or more regular galls on leaves and others (*Schedotrioza*) make woody galls on eucalypt leaves.

Diptera.

In addition to the gall midges (Cecidomyiidae), many species of which cause galls and create considerable economic hardship through ravaging crops, gall-forming occurs in some fruitflies (Tephritidae) and, one of the most unusual groups in Australia, in the near-endemic family Fergusoninidae. The only cecidomyiid of major economic importance in Australia is the introduced Sorghum midge, *Contarinia sorghicola*, which can cause substantial crop loss – up to 50% or more – through large amounts of gall tissue, massive numbers, hampering photosynthesis, and diverting nutrients so that only severely stunted plants result. More generally, Cecidomyiidae is one of the largest families of Diptera, and gall-formers constitute a high proportion of its largest subfamily, Cecidomyiinae (Harris 1994).
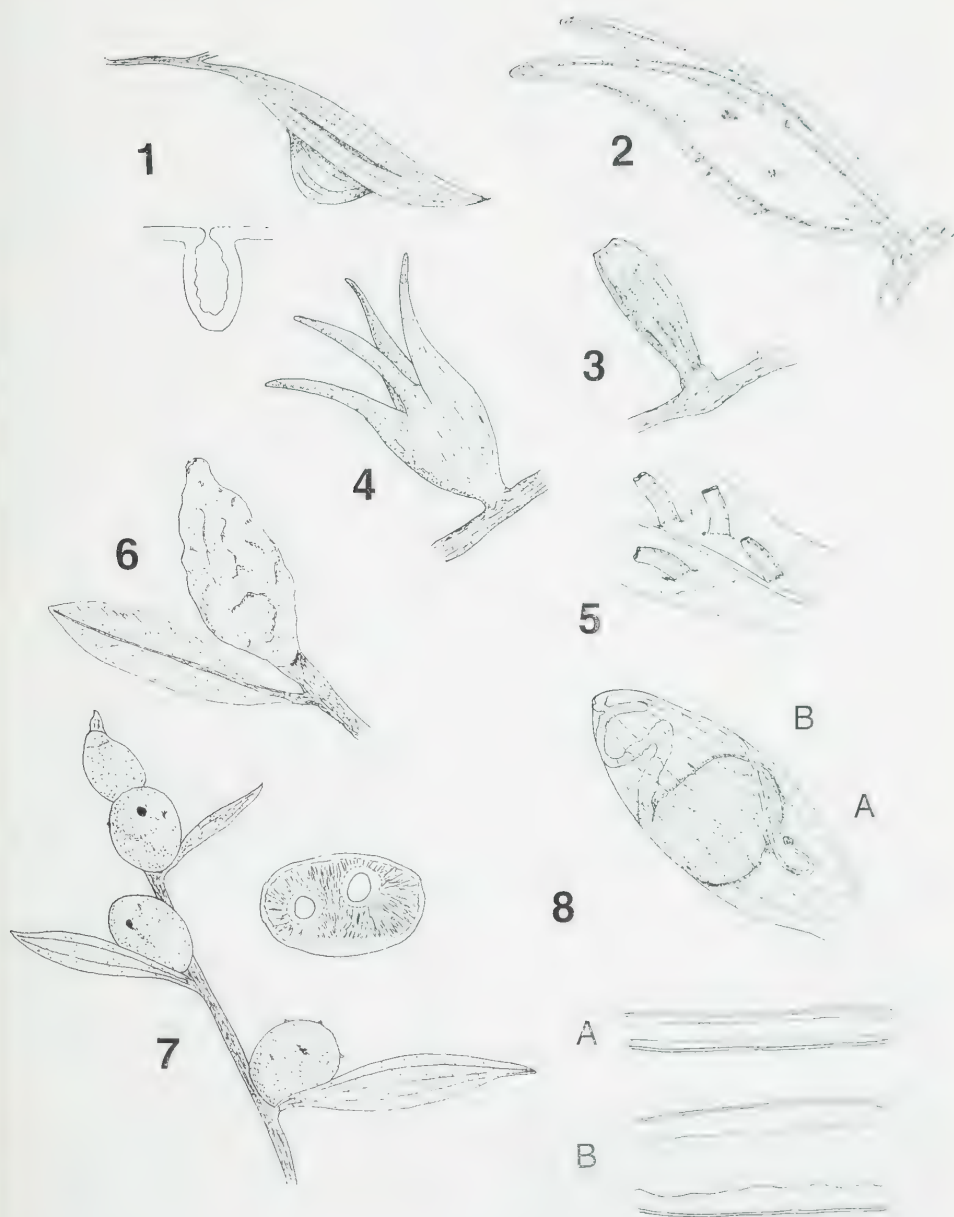
Figs 1-8. Representative galls of insects in southeastern Australia, to illustrate range of forms (not to scale): 1, Thysanoptera, the pouch gall of *Kladothrips rugosus* on *Acacia* phyllode, with inset of section through gall; 2-5, Homoptera, coccid galls on *Eucalyptus* (2) *Apiomorpha duplex*, (3) *A. conica*, (4) *A. munita*, all female galls. (5) *Apiomorpha* sp., male galls on leaf; 6, Diptera, spongy gall of *Fergusonina* sp. on *Eucalyptus*; 7, Hymenoptera, galls of pteromalid wasp, *Trichilogaster* sp., on *Acacia*, with inset of section through gall with two chambers shown; 8, Lepidoptera, the mine-gall transition of a gracillariid moth, *Epicephala* sp., on *Acacia*: A shows cross section of normal phyllode, B shows increased thickness through gall region, due to formation of callus tissue.

Most of the 25 or so species of *Fergusonina* have unique associations with nematode worms in their galls on *Eucalyptus*, and form a commensal existence: the relationships were the subject of a classic account by Currie (1937). Most species have been little-studied since then, although the biology of one was discussed by Taylor *et al.* (1996). Female nematodes enter the body of female fly larvae in the gall, and their progeny make their way to the ovaries of the developing fly, and are thence passed with eggs into new sites (flower buds, leaf buds, apical tips, leaves, or stems, depending on the fly species) during oviposition. Nematodes invade the plant tissues and multiply within the fly gall and, in due course, complete the cycle by entering fly larvae. Their galls on eucalypt stems can be soft and 'spongy'.

Hymenoptera. In the Holarctic region, the predominant gall-forming wasps belong to the superfamily Cynipoidea, which have radiated extensively on oaks *Quercus*, and which are by far the most thoroughly documented group of gall insects. These wasps are poorly represented in Australia, and the gall-forming role has been assumed by some members of another major group, the superfamily Chalcidoidea (most members of which are tiny wasps parasitoid on other insects) as ecological homologues (fulfiling similar ecological roles in a different environment) of the northern gall-forming cynipoids.

The major species involved are members of the family Pteromalidae, in particular the *Acacia*-infesting species of *Trichilogaster*. Their biology was documented in a series of papers by Noble (1938, 1940, 1941). The univoltine (one generation each

Fig. 9. *Trichilogaster* wasp galls on *Acacia*

year) wasps can form vast numbers of 'marble galls' in inflorescence buds (Fig. 9), axillary buds or other young growth of particular acacias, and all developmental stages of the wasps are passed within the woody gall. Galling results in mass loss of inflorescences and seeds, and can cause localised dieback on the trees both directly and by causing increased premature loss of foliage: they are thus often noticed in gardens. Interest in *Trichilogaster* has resurged over the last decade or so because of the need to control several Australian acacias which have become environmental weeds in South Africa. *Trichilogaster acaciaelongifoliae* was introduced there as a biological control agent in 1982/83, and has been spectacularly successful in some sites (Dennill 1985, 1988), causing up to 99% reduction in seed production in *A. longifolia* on some Cape Province sites. The severe effects imply a large committment of the plant's energy to gall production (Dennill and Donnelly 1991), and multiple galls are common.

Gall communities

Primary gall-formers provide resources for a great variety of other insects, which may be predators and/or parasitoids of the gall species or simply those which adopt the gall as a place to live, commonly termed 'inquilines'. The latter coexist with the gall-former, many of them feed on gall tissue, and may also attract specific natural enemies. Because of these extended feeding webs, most galls are not restricted to a simple 'plant-galler' interaction but form the basis of a broader community. Many of these other inhabitants are also ecologically specialised, and depend on the gall environment for their own wellbeing.

Non-insect galls can also form the basis of characteristic insect assemblages. The uredineine fungus *Uromycladium tepperianum* forms large woody galls on many species of *Acacia* in Australia, and dead galls may persist for several years (Burges 1934). Insects exploit such fungus galls for food or shelter, and many have been reared from *Uromycladium*. The complex near Melbourne includes about seven species of Lepidoptera, for example, and larvae of most of these tunnel in the galls throughout their development (New 1982).

Concluding comment

Despite their biological intricacies and intrigues, as exemplified above, very little is known about most insect-gall interactions in Australia, and substantial contributions can be made easily by patient naturalists. As with so many aspects of entomology, such fundamental documentation is by no means the province solely of professional scientists. There are still no comprehensive accounts of the host spectrum of most gall-forming insects and the relative abundance of many taxa, let alone studies of their development, phenology, and interactions with other members of the community. Although the desires to utilise some species as biological control agents against some pest taxa have focussed attention on these, most other species have been relatively neglected.

Even such simple exercises as making collections or surveys of galls on our most abundant native plants, and rearing the inhabitants over a period, will surely contribute new and fascinating information to the topic.

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The Enigmatic Marion Wright: Our Unknown Benefactor

Sheila Houghton*

During its long history the Field Naturalists Club of Victoria has benefited from numerous bequests by people for whom the Club has provided interest and involvement over varying periods of time. Of all these bequests, that of Marion Wright is the most curious.

In August 1962 Eustace Coghill, Honorary Secretary of the Field Naturalists Club of Victoria, received a letter from the West Australian Trustee informing him that under the will of Marion Wright, the Club was the residuary legatee of her estate.[1] Mystified, Eustace Coghill, acknowledging the letter, inquired whether the West Australian Trustee had any idea why this bequest had been made, since no-one had heard of Marion Wright, who did not appear in any membership list, and there seemed to be no evidence of any previous connection with the Club.[2] The West Australian Trustee was silent on this matter.

Marion Wright owned 33-35 Lindsay Street, Perth, close to the city. She occupied No. 35, and No. 33 was let to a person called Oliver. The ensuing correspondence makes intriguing reading. At the time of her death Marion Wright lived alone; she was found dead in her house on 18 July 1962, which is given as the date of death, though she may have died sometime the previous day. The West Australian Trustee was clearly shocked by the condition of the house, which he thought should have been condemned by the health authorities. He warned that there would be costs involved in having the house cleared; he added that the Certificate of Title had not been found, and that obtaining a new one would be another charge on the estate. The title deed was subsequently found, and the contents of the house were carted away to the Council tip in three truckloads, at a cost of £25.[3] The few pieces of furniture were valued at £15.10s.[4] The tenant in No. 33 moved out and the proposal to auction the property (both lots were on one title deed) was approved by the Club,[5] and in 1963 the property was sold for £2,500.[6] The Field Naturalists Club of Victoria received in total £2,608.8s.3d. from this unknown benefactor.

So who was Marion Wright, and why did she leave her estate to the Field Naturalists Club of Victoria? The only clues left behind were in her will. She directed that £50 be allocated 'for the purchase and erection of a suitably inscribed marble headstone on my grave'.[7] She is buried in the Anglican section of Karrakatta Cemetery, Perth, and the inscription reads 'In loving memory of Marion Wright. Died 18 July 1962. Aged 85 years.' (The cost of this was £52.4s.6d.)[8] The death index states that her parents were unknown, and she is not included in the West Australian Pioneers Index. This, together with the fact that she bequeathed £80 to be paid in London in English currency, to her sister, Mrs Ellen King, of Woking, Surrey, England suggested that Marion had been born in England.

Marion Wright was born in Whitechapel in 1876, the daughter of Henry and Mary Wright. Henry is described in the 1881 census as a coach trimmer. At that date Marion had an older sister Florence (b.1874) and a younger brother Edward (b.1878). Ellen appears to have been nine years younger than Marion, born in 1885.

Positive identification is impossible, but it seems highly likely that Marion arrived in Western Australia in 1897. A Miss M. Wright disembarked from R.M.S. *Arcadia* at Albany on 25 November 1897, along with three families; the Stones, the Pearsons and the Cookes, and three single men who all embarked in London; and Bishop Riley, who was returning from the Lambeth Conference, and joined the ship in Brindisi.[9] Bishop Riley was much concerned with the plight of the London poor, and it is not impossible that he played some part in Marion's emigration to Western Australia. However, it is probably just coincidence that they happened to arrive in the same ship. Miss M. Wright's name appears on the passenger list immediately after that of the Stone family, which suggests she may have been a servant or nursemaid to them.[10]

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This supposition is borne out to some extent by Marion's next emergence in the records, on the 1914 electoral roll for Perth, at the Esplanade Hotel, described as 'lady help'.[11] Where she was between 1897 and 1914 has not been established, but it seems likely that she was in private service, probably as a lady's maid. On the 1916 and 1917 electoral rolls she is described as 'hotel employee'.[12] From 1921 to 1932 she was at the Savoy Hotel, employed in domestic duties.[13] The Post Office Directory gives her address from 1925-1930 as 451 Hay Street East, apartments.[14] Marion, it would seem, was already seeking to secure her financial future. In 1935 she bought the property in Lindsay Street. Her address on the title deed is 35 Lindsay Street, so she was evidently renting the house, which she may have done from 1931 when the previous owner died, and the estate passed to the executor.[15] In 1935 Marion would have been nearing sixty and the end of her working life.

The West Australian Trustee informed the Field Naturalists Club of Victoria that Marion Wright had held a trust account for Walter Charles Truscott, but he had died five months previously, and the money had reverted to Marion.[4] He, too, is buried in Karrakatta Cemetery, in an unmarked grave. Records show that he was aged 79, and his parents were unknown.[16] Electoral rolls in the 1920s describe him as a clerk.[17]

Earlier research, attempting to establish a link between Marion Wright and the Field Naturalists Club of Victoria, had focussed on the possibility that she had spent some time in Melbourne, and possibly had worked for Fred Lewis. This was based on the fact that his name and address were mentioned as Honorary Secretary of the Club in her will. The will was made on 24 July 1959. Fred Lewis was secretary from 1950 to 1956, dying in that year. It would appear that his name was obtained from an old issue of *The Victorian Naturalist* and this was as random as the selection of the Field Naturalists Club of Victoria as her residuary legatee seemed to be.

To gain further insight into the character and activities of Marion Wright seemed impossible, when, unexpectedly, a letter arrived from Jim Oliver. He is the son of the tenant at 33 Lindsay Street at the time of Marion's death. Jim had lived there with his mother from 1950 to 1958, and had known Marion Wright from the early 1940s, when she was known to the children of the district as 'that funny old lady' from Lindsay Street. He said that she was often seen with shopping bags collecting twigs from the local park, in quantities which puzzled them, being in excess of what she would have needed for fuel, and when she died there was a room full of them; which no doubt added to the West Australian Trustee's dismay. She also used to scatter crumbs and food scraps on the street verge, explaining that 'It's for the birds'. Jim Oliver said that Marion Wright was always poorly dressed and seldom went out except for shopping and to collect the twigs. Wally Truscott also lived at No. 35, and Jim Oliver described him as 'a drunken, mostly nasty little ex-jockey'.[18] This may explain why Marion Wright held a trust account for him, to make sure of his rent, and perhaps to limit his access to alcohol.

The mystery remains. Simply a random, eccentric choice of legatee. Gathering twigs and feeding the birds hardly seems sufficient evidence of an interest in natural history, and provides no link with a Victorian natural history club. But Marion Wright, who led an obscure life, helped to establish the Club in its present position, and by her inexplicable act has secured for herself a small niche in history.

Endnotes

1. Letter from W.A. Trustee to Hon. Secretary 3 August 1962. *FNCV Archives* 101 -027.
2. Letter from E.H. Coghill to W.A. Trustee 29 August 1962. *FNCV Archives* 101-029.
3. Letter from W.A. Trustee to Hon. Secretary 21 January 1963. *FNCV Archives* 101-032.
4. Estate of Marion Wright, Affidavit Verifying Statement. Schedule D. *FNCV Archives* 101-031/4.
5. Letter from E.H. Coghill to W.A. Trustee 8 February 1963. *FNCV Archives* 101-033.
6. Letter from W.A. Trustee to Hon. Secretary 28 March 1963. *FNCV Archives* 101-034.
7. Will of Marion Wright 24 July 1959 (copy). *FNCV Archives* 101-028.
8. Estate of the late Marion Wright 3 May 1963. *F NCV Archives* 101-036/1.
9. Passenger Lists: Arrivals Index (Albany) 1873-1925.
10. ibid.
11. Electoral roll Perth 10.September 1914.
12. Electoral rolls Perth May 1916 - August 1917.
13. Electoral rolls Perth 1921 - 1932.
14. West Australian Post Office Directories 1925-1930.
15. Title Deed.
16. West Australian Death Index.
17. Electoral rolls Perth 1922 -1929.
18. Letter from Jim Oliver to the Author 10 September 1996.

From our Naturalist in Residence, Ian Endersby

Tide-watching or The Pull of the Moon

Birdwatchers like high tides because they concentrate into compact areas all of those waders that have ventured south from their Arctic breeding grounds to spend summer in Australia. If the tide is out only distant silhouettes can be discerned through the heat shimmer across the broad mud flats. That is useless if you want to identify the birds and estimate their population numbers. On the other hand rock pool ramblers and littoral specialists need low tides to observe their plants and animals and work out the complex behaviours that enable them to survive in a daily twice wetted environment that suffers extreme temperatures and salinity. Instead of complaining because we misjudged the time, perhaps we should do some tide-watching instead and see what we can learn.

The first thing that becomes obvious is that at most places there are about two high and two low tides a day. In fact, the interval between two high tides is 12 hours 25 minutes and so high tide occurs a little later each day. At some times the high tides are higher than others and the low tides are lower. Those events which have the greater tidal range are called 'Spring' tides, and they are interspersed with 'Neap' tides when the range is at a minimum. This follows a cycle that is approximately monthly. Consecutive high tides do not always reach the same height; there can be a high 'High' tide followed by a lower 'High' tide half a day later and this has nothing to do with Spring and Neap. Also, if we were to measure the tides very accurately, we would find that there is an annual variation superimposed on all of the other movements.

It is no coincidence that the time between consecutive tides is half that of the time that the moon takes to circle the earth because, as most people already know, it is the moon which has the dominant effect on tides. As we can see in the diagram the Moon attracts the waters of the Earth causing a 'bulge' in the sea and, due to

centrifugal forces, there is a corresponding bulge on the opposite side, albeit not quite as high. As the Earth rotates through the bulge it experiences a high tide, so that is why there are two per day interspersed with two low tides. That is the general principle of tides, but there are lots of complicating factors. For one thing, the tidal bulge does not correspond to the passage of the Moon over the meridian. Due to the varying shape of the land and sea bed at each location, which causes differences in the rates of tidal flow, the tides will lag behind the transit of the Moon.

What has all this to do with the Naturalist who can check the tides in the daily newspaper before planning an expedition. To me, being a naturalist means seeking plausible explanations for behaviours observed in the natural world. The behaviours of tides is just as rich a field for observing and postulating as that of any bird, insect or geological formation. Because of the navy's interest in the subject over hundreds of years much of the thinking has been done but let us try to tie it together from what we know ourselves.

The gravitational pull of the Sun also has an effect on tides but, as it is so much further away, it is not as great as that of the Moon. We should expect to see the highest tides when the Sun and the Moon are pulling in the same direction. At Full Moon, when one rises as the other sets, Sun and Moon are exactly opposite, that is why the whole face of the moon is lit. That should give us a Spring tide. Similarly, at New Moon when the two bodies are again in line but it is the back of the moon that is fully lit, our side is dark, we should have another Spring tide. I would expect the New Moon Spring Tide to be slightly higher than that of the Full Moon, but there are too many confounding factors for me to be able to measure this. At First and Third Quarter Moons, when Sun and Moon are at right angles, we should get the Neap tides.

Have another look at the diagram. If Sun

and Moon are directly over the equator the two parts of the tidal bulge would be symmetrical and both tides in the day would rise to the same height. However, this does not occur often and the asymmetry shown explains why a high High tide is followed by a low High Tide at the southern latitude drawn. The Moon goes from its maximum northerly declination to its maximum southerly declination in a period of about four weeks.

Finally, we must remember that Kepler deduced that '*every planet moves in an elliptical orbit, the Sun being at one focus*'. This also applies to the motion of the Moon about the Earth and so we have the prime tide-generating bodies at some times being closer to the Earth than at others. The tides will be higher when those bodies are closer. The Moon moves from apogee to perigee in just under a calendar month and the Sun moves from aphelion to perihelion over the course of a year. I was not surprised to read that the nine harmonic tidal constants used for predicting the tides at Port Phillip Heads were based on sixty constituents.

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56 Looker Road, Montmorency, Victoria 3094.
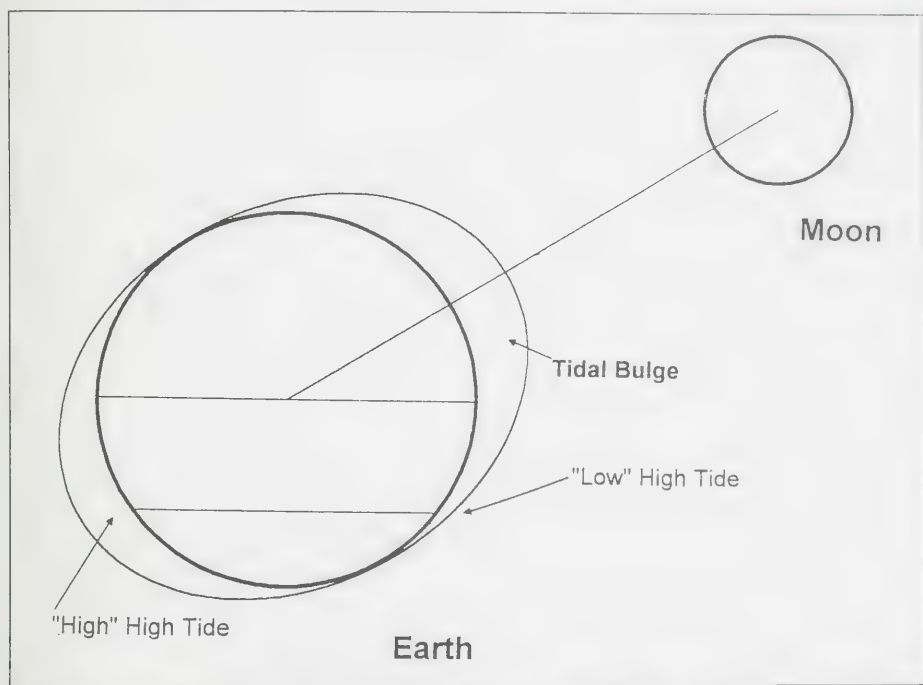
Schematic representation of how the tidal bulge produces twice-daily asymmetric tides.

The Victorian Naturalist - Special Issue
100 Years - Mt Buffalo and Wilsons Promontory

We would like to receive articles or short notes for this special issue of the journal on the history, the people involved and the natural history of these two parks, especially anything involving the FNCV.

If you can help by writing for us, please contact Ed or Pat Grey (03) 9435 9019, or write to:-

The Editors, *The Victorian Naturalist*, Locked Bag 3, PO Blackburn, Victoria 3130.

Wildflowers of Southern Western Australia

by Margaret Corrick and Bruce Fuhrer,
edited by Alex George

Publisher: *Five Mile Press in association with Monash University, 1996;
224 pages, hardcover; RRP $39.95*

This excellent book fills a real gap in the readily available information covering the amazing Western Australian wildflowers, in that the 755 featured plants are grouped according to botanical families. This taxonomic approach enables the reader to access information on groups of plants having some degree of affinity and similarity. Finding the names of a given plant is also easier than having to search through pages of alphabetical listings to find an illustration that matches the plant under scrutiny. Of course, the Western Australian flora does contain some plants whose botanical affinities are far from easy to recognise, which is where a book based on ecological associations adds another dimension to the process of identification. Such a book is *Flowers and Plants of Western Australia* by Rika Erickson, A.S. George, N.G. Marchant and M.K. Morcombe, 1986.

But to return to the Corrick and Fuhrer book, by and large the photographs are a model of clarity, whilst the descriptions of both of the plants and the habitat in which each grows, further help in narrowing down the possible options. The index is comprehensive, covering not only botanical and common, but also family, names. I like too the fact that a brief description of features characterising a particular genus are included e.g, *Petrophile* vs *Isopogon*; also that there are clear maps and an overview of the various botanical regions of Western Australia. A small criticism is that there is no indication or listing of other similar plants assoociated with each description - a feature I particularly like in the Identikit series.

Both authors and the editor are highly regarded in their fields and they have come together to produce a book that is not only useful but also very attractive. The appeal of the book is well and truly borne out by the fact that in a little over six months since its publication, it is already sold out and a second printing has been made. This second printing incorporated the corrigenda issued for the first printing.

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MEMBERSHIP

Members receive *The Victorian Naturalist* and the monthly *Field Nat News* free. The Club organises several monthly meetings (free to all) and excursions (transport costs may be charged). Research work, including both botanical and fauna surveys, is being done at a number of locations in Victoria, and all members are encouraged to participate.

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The Victorian Naturalist

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Volume 113, 1996

Compiled by K.N. Bell

Issue 4 (August 1996) commemorates 100 years since the death of
Baron Ferdinand von Mueller
with articles on various aspects of his life.